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Volume 13, Number 1, January 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL RADIOACTIVITY IN MICHIGAN, 1970. *Samuel Wieder, Joe E. Logsdon, and Charles P. Froom. Radiation Data and Reports, Vol. 13, January 1972*, pp. 3–18.

This report summarizes the radioactivity from all major sources measured in the Michigan environment during 1970. It also describes the State's environmental surveillance programs and the data resulting from these programs. Surveillance data provided by Federal, State, operator, and contractor sources are summarized. On the basis of this information, an estimate is presented of annual radiation doses to the population of Michigan. A summary of some operating characteristics of Big Rock Point, Enrico Fermi-1 and Palisades plants is presented.

KEYWORDS: Michigan, environmental, nuclear power, radioactivity, reactors, surveillance.

A SUMMARY OF ENVIRONMENTAL RADIATION SURVEILLANCE ACTIVITIES IN ARKANSAS. *Burvie H. Sheets, William H. Oates, Jr., David D. Snellings, Jr. and E. Frank Wilson. Radiation Data and Reports, Vol. 13, January 1972*, pp. 19–26.

This report describes the environmental radiation surveillance program of the Division of Radiological Health, Arkansas State Department of Health. The program has been broken down into two general categories: (1) statewide system and (2) source oriented surveillance activities. There are two nuclear facility sites in Arkansas and extensive surveillance activities are presently being conducted near each site. Some of the data that was collected during the time period 1966 through 1970 has been presented.

KEYWORDS: Arkansas, air, grass, milk, offsite surveillance, nuclear power reactor, radioactivity, silt, soil, water.

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Radioactive Discharges and Environmental Surveillance Associated with Nuclear Power Plants

Radioactivity in the environment has many sources, and these result in population exposure through several pathways. In order to estimate population dose from environmental radiation it is necessary to know the concentrations or levels in each exposure pathway. The reduction or control of population exposure requires a knowledge of the sources of environmental radiation and of the pathways from these sources to man.

The sources of greatest environmental radiation exposure to the population are natural background radioactivity and fallout from past nuclear weapons tests conducted in the atmosphere. These sources generally do not lend themselves to control, but because of their variability with time and location, it is important to measure them on a continuing basis in order to ascertain and to evaluate any contributions that may arise from controllable sources of environmental radiation. Cognizance is taken of the impact of medical x-ray exposure on the population through the genetically significant dose concept.

Nuclear facilities which release radioactive wastes to the environment represent a controllable source of environmental radiation; hence it is appropriate to assess the contribution of these sources to population dose. Releases from nuclear power operations contribute a very small part of the total population exposure to ionizing radiation. Such releases, however, increasingly engage the concerns of environmental and public health authorities and the public, because the number and output of nuclear power and supporting facilities are increasing. A measure of the projected increase in nuclear power plants in the United States may be obtained from the following tabulation:[1]

	Number	Capacity (kWe)
Plants operable	22	9,131,800
Plants being built	55	46,605,000
Planned (reactors ordered)	49	48,524,000
Totals	126	104,260,800

For purposes of gaining perspective with respect to population exposure in the light of the anticipated growth of the industry, it is important to document such factors as: releases to the environment, population distributions around reactor sites, and all sources and vectors that bear upon radiation exposure to people in the region that may be materially affected by releases of radiation from nuclear power operations.

Data on radiological surveillance of areas in which nuclear power reactors are situated will be reported as they become available, on a regional or State-by-State basis, as appropriate. As this program proceeds it is anticipated that a perspective of the national picture will develop. *Radiation Data and Reports* will present data for various regions or States on a rotating basis, so that as many regions as can feasibly be covered may be represented during each year.

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[1] As of September 30, 1971; source, AEC news release.

Data sources will include reactor licensees, the Environmental Protection Agency, the Atomic Energy Commission and its contractor facilities, States, and special contractors such as universities and others. As a basis for the presentation of these surveillance reports, it will naturally be necessary for the State or region to have one or more nuclear facilities with associated surveillance programs, including data on discharges of radioactivity.

With the development of guides to the preparation of environmental reports for nuclear power plants, it is anticipated that regional reports will become more complete and increasingly amenable to intercomparison.

In this issue of *Radiation Data and Reports*, data are presented which relate to environmental radioactivity in Michigan for 1970.

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Reports

Environmental Radioactivity in Michigan, 1970

Samuel Wieder, Joe E. Logsdon, and Charles P. Froom[1]

This report summarizes the radioactivity from all major sources measured in the Michigan environment during 1970. It also describes the State's environmental surveillance programs and the data resulting from these programs. Surveillance data provided by Federal, State, operator, and contractor sources are summarized. On the basis of this information, an estimate is presented of annual radiation doses to the population of Michigan. A summary of some operating characteristics of Big Rock Point, Enrico Fermi-1 and Palisades plants is presented.

The State of Michigan had two nuclear power plants functioning during 1970—Big Rock Point and Enrico Fermi–1. The Big Rock Point facility has been in operation since 1962. The Enrico Fermi–1 plant, a fast breeder reactor which began operations in 1963, was shutdown in October 1966 as a result of fuel element damage. It resumed full power tests late in 1970. Although the Palisades plant was originally scheduled to start up in 1970, test operation at low power (not to exceed 1 megawatt thermal) did not begin until the spring of 1971. A summary of some characteristics of operating and planned nuclear power plants in Michigan appears in table 1; their locations are shown in figure 1.

Data on the environmental impact of the Big Rock Point plant—the only nuclear power reactor operational during the entire year—are too limited for 1970 to permit accurate estimates of dose to the local population, and some types of sampling showed radioactivity levels no higher than are normally found in Michigan. However, an estimate of the maximum hypothethical dose to an individual, based on conservative assumptions is attempted. With expanded and coordinated data collection in the future, more accurate assessments of population exposures should be possible.

A variety of radioactivity surveillance studies have been made in the State. Routine surveillance activities are conducted by the Michigan Department of Public Health, Michigan Water Resources Commission (Department of Natural Resources), the Environmental Protection Agency (EPA), and the nuclear power plant operators. A summary of these programs is provided in table 2. In addition, special surveys of Lake Michigan were performed by the University of Michigan for 1969–1970. Argonne National Laboratory also determined environmental radionuclide concentrations near the Big Rock Point reactor.

Environmental surveillance around nuclear power reactors

Big Rock Point

Big Rock Point Nuclear Power Station uses a boiling water reactor. Among other specifications, its design characteristics provide for high-efficiency particulate filters and piping to permit 30-minute delay prior to discharge of gases through a 240-foot stack. Initial dilution of radioactive gases is provided by a flow of 30,000 cubic feet per minute of ventilation air. Gaseous waste discharges are limited by technical specifications to 1 curie per second for fission and activation gases.

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[1] Messrs. Wieder and Logsdon are with the Surveillance and Inspection Division, Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460. Mr. Froom is with the Bureau of Radiological Health, FDA.

Table 1. Nuclear power facilities in Michigan

Name of facility	Operator	Reactor type[a]	Power level (MWe)	Year of startup	Location	Population within 10 miles[b]
Big Rock Point	Consumers Power Company of Michigan	BWR	70.3	1962	Big Rock Point	11,000
Enrico Fermi-1	Power Reactor Development Company	FBR	60.9	1963	Lagoona Beach	61,000
Palisades	Consumers Power Company of Michigan	PWR	700	1971	South Haven	28,000
Donald C. Cook-1	Indiana and Michigan Electric Company	PWR	1,054	1972	Bridgman	
Donald C. Cook-2	Indiana and Michigan Electric Company	PWR	1,060	1973	Bridgman	
Midland-1	Consumers Power Company of Michigan	PWR	492	1974	Midland	
Enrico Fermi-2	Detroit Edison Company	BWR	1.123	1973	Lagoona Beach	
Midland-2	Consumers Power Company of Michigan	PWR	818	1975	Midland	

[a] BWR-boiling water reactor; FBR-fast breeder reactor; PWR-pressurized water reactor.
[b] Operating facilities only.

Liquid radioactive waste discharges average about 780 gallons per day from various plant drains, demineralizer regeneration liquids, laundry, and miscellaneous low-level wastes. The system is designed to handle about 70,000 gallons per day.[2] Releases are on a batch basis under controlled flow. These wastes go into a discharge canal and thence into Lake Michigan.

The Big Rock Point reactor has been part of an extensive research and development program testing fuels and fuel claddings. Consequently, it has experienced more fuel failures—and thus has had more fission products in its waste effluents—than might be expected if operations were of more routine nature.

The operating history of the Big Rock Point reactor was summarized in a report by Logsdon and Chissler (*1*). In general, gaseous waste discharges tended to increase during the first few years of operation. Then beginning in 1967, with continued operation, they declined, although there was no reduction in power generation. No similar trend was ascertainable in liquid waste discharges. During 1970, total curies of gross beta activity, less tritium, in liquid-waste discharges were 61 percent less than during the previous year. Total curies of gaseous waste discharges were down 15 percent in 1969 and up 38 percent in 1970.

Table 3 lists, for 1970, gross beta analyses of environmental samples for various locations around the Big Rock Point plant. Comparison of these data with similar data collected around Palisades—which was not yet in operation—(table 3 and 10) indicates some radioactivity increase in air or precipitation around Big Rock Point. However, comparison of data on radioactivity in shore minnows collected near the Big Rock Point reactor indicated an increase of from 10 to 30 times the radioactivity in minnows collected in the vicinity of the Pali-

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[2] The primary source of liquid waste radioactivity resulted from regeneration of condensate demineralizer resins. Early in 1971, an administrative procedure was enacted to discontinue regeneration and discard the resins for offsite burial when spent. This has substantially reduced the amount of radioactive liquid waste discharged to the lake (personal communication, R. W. Linderman, Consumers Power Company).

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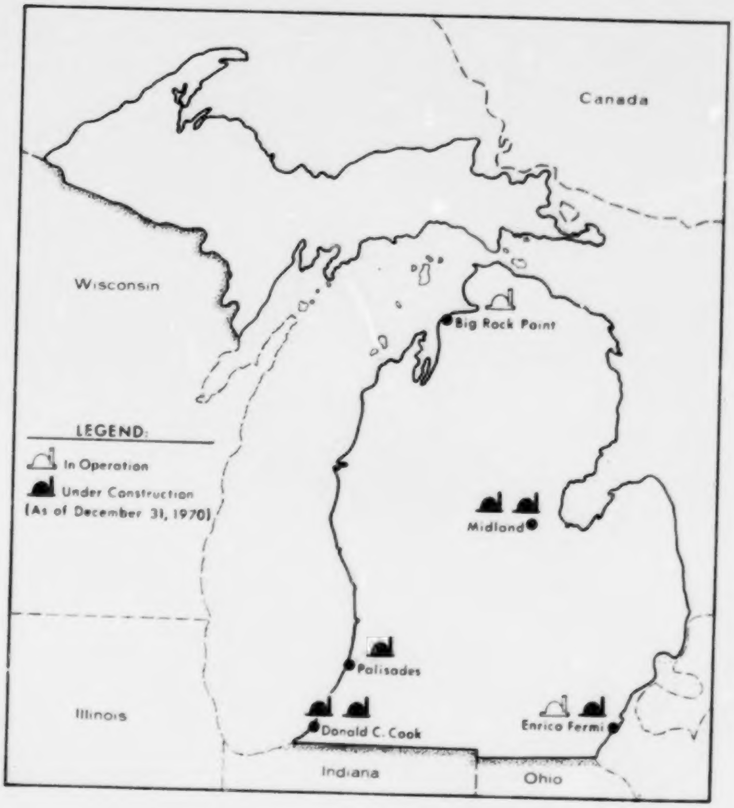

Figure 1. Nuclear power plants in Michigan

sades plant. The data from samples of filamentous algae collected near Big Rock show concentrations of radioactivity approximately three times greater than in similar samples collected near Palisades.

During June, July, and October 1970, Argonne personnel collected water, sediment, and biological samples near Charlevoix, and analyzed these for gamma-ray emitting nuclides (2). A summary of the findings follows.

Water The radioactive effluent from the Big Rock Point reactor (which is mixed with the cooling water and discharged through a shoreline channel) consists of periodic releases of liquid waste. This variability of source activity—in addition to the variable nature of lake currents—decreases the usefulness of data derived from short-term samples taken at some distance from the source, e.g., from Lake Michigan waters. Table 4 shows concentrations of five gamma-emitting radionuclides in samples of water collected with a Battelle large volume ocean sampler, which forces water through a filter and ion-exchange-resin-bed combination. These data show easily measured concentrations in the discharge channel and detectable levels as far as ¼ mile beyond the channel.

Near-shore organisms For purposes of defining the area of influence of the radiation from waste discharges at Big Rock Point, measurements of radionuclide concentrations were made in organisms at various distances from the point of discharge. The organisms investigated were either attached to the bottom or had a limited range, and were both abundant and easy to gather. These were counted wet and then oven-dried at 100° C. to obtain dry

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Table 2. Summary of surveillance programs in Michigan, 1970

Sample type	EPA Network			State Program			Enrico Fermi Program			Palisades Program			Big Rock Point Program		
	Number of sample locations	Frequency of collection	Type of analysis	Number of sample locations	Frequency of collection	Type of analysis	Number of sample locations	Frequency of collection	Type of analysis	Number of sample locations	Frequency of collection	Type of analysis	Number of sample locations	Frequency of collection	Type of analysis
Air particulate	1	Daily	Gross β	14	Weekly	Gross β	10	Weekly	Gross β	12	Weekly	(a)	7	Weekly	Gross β, ^{131}I
Surface water	4	Quarterly	^{3}H	51	Annually	Gross β	8	Weekly	Gross β	1	Monthly composited quarterly	Gross β, Gross γ, ^{3}H, ^{137}Cs, ^{90}Sr, ^{131}I	[b]2	Monthly composite	Gross β, Gross γ, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{137}Cs
Precipitation	1	Daily	Gross β	14	Weekly	Gross β	5 offsite 5 onsite	Monthly Monthly	Gross β Gross β ^{141}Ce, ^{144}Pr, ^{95}Zr-Nb, ^{103}Ru, ^{106}Ru-Rh, ^{54}Mn, ^{137}Cs						
Well water										3	Monthly	Gross β, ^{131}I, ^{137}Cs, ^{90}Sr, ^{59}Fe, ^{60}Co, ^{65}Zn			
Drinking water	1	Quarterly	^{3}H	48	Quarterly	Gross β Gross α									
Sediment							2	Quarterly	^{137}Cs, ^{226}Ra, ^{40}K						
Human bone	Varies 21 in 1970	Varies	^{90}Sr/Ca ratio												
TLD and film				14	Monthly	Gamma dose	10	Monthly	Gamma dose	[c]21	Monthly and quarterly	Gamma dose	[d]21	Monthly	Gamma dose
Vegetation										5	Monthly in season	Gross β, Gross γ			
Milk	2	Weekly Jan–June monthly July–Dec	^{89,90}Sr, ^{137}Cs, ^{131}I, ^{140}Ba	8	Weekly an monthly	^{90}Sr, ^{137}Cs, ^{131}I, ^{140}Ba-La	4	Monthly	Gross β, ^{137}Cs, ^{40}K	3	Monthly	^{131}I, ^{90}Sr, ^{137}Cs, ^{140}Ba-La			
Fish				6	2/a	Gross β	4	Quarterly	Gross β, ^{141}Ce, ^{144}Pr, ^{95}Zr-Nb, ^{103}Ru, ^{106}Ru-Rh, ^{54}Mn, ^{137}Cs						
Other aquatic biota				6	2/a	Gross β				1	Varies	Gross β, Gross γ, Gamma scan	5	Annually	Gross β, Gross γ, Gamma scan

[a] Gross β and ^{131}I analysis at all sites; ^{90}Sr, ^{137}Cs, and ^{140}Ba-La at only one site.
[b] Condenser cooling water inlet and outlet; radionuclide analysis only on outlet sample.
[c] Includes 9 on the site boundary.
[d] Includes 14 on the site boundary and control dosimeters.

Table 3. Gross beta radioactivity in environmental samples, Big Rock Point Reactor, 1970

Sample type	Location	Distance from Big Rock Point plant	Frequency of collection	Radioactivity		Number of samples
				Range	Mean	
Air particulate[a] (pCi/m³)	Charlevoix	4 miles-SW	Weekly	0.059– 0.80	0.259	51
	Reactor site			.063– .70	.256	49
	Burgess	2 miles-ESE		.073– .88	.268	51
	Nine Mile Point	3 1/2 miles-ENE		.069– .71	.224	47
	Oyster Bay	2 1/2 miles-S		.067– .94	.260	52
					0.252	250
Air particulate[b] (pCi/m³)	Big Rock Point Plant		Weekly	.010– .40	.11	52
	Nine Mile Point	3 1/2 miles-ENE		.010– .41	.19	53
	Charlevoix	4 miles-SW		.014– .53	.12	53
	South of Susan Lake			.014– .44	.15	23
	Petoskey			.010– .40	.13	49
	Boyne City			.010– .52	.15	37
	Traverse City			.020– .57	.12	42
					0.14	309
Precipitation[a] (pCi/liter)	Charlevoix		Weekly	.17 – 49	16.5	19
	Reactor site			.37 – 91	30.0	19
	Burgess			1.3 – 120	33.2	19
	Nine Mile Point			.69 – 130	48.1	20
	Oyster Bay			1.8 – 120	36.2	18
					32.8	95
Deposition from precipitation[a] (pCi/m²-day)	Charlevoix		Weekly	1.5 – 130	39.8	19
	Reactor site			3.6 – 230	88.9	19
	Burgess			5.7 – 230	98.6	19
	Nine Mile Point			5.0 – 280	116.2	20
	Oyster Bay			7.1 – 230	88.8	18
					86.5	95
Drinking water[a] (pCi/liter)	Samples from 48 sites	Throughout State	Quarterly to semiannually	< .94 – 8.4	3.1	107
	Charlevoix			2.0 – 3.4	2.7	
	Petoskey			2.0 – 3.6	2.8	
	Traverse City			3.2 – 4.2	3.7	
	Elk Rapids			<.94 – 2.4	1.7	
Surface water[a] (pCi/liter)	Lake Michigan-Charlevoix			ND–10	9	
	Susan Creek at U.S. 31			ND	ND	
	Little Traverse Bay, 2 miles west of Petoskey			ND	ND	
	Lake Michigan-Petoskey			ND	ND	
	Bear River-Petoskey			ND–16	11	
Filamentous algae[c] (pCi/g)	Big Rock Point Plant		2/annum	340 – 340	340	2
	Nine Mile Point	3 1/2 miles-ENE	2/annum	112 – 120	116	2
	Mt. McSauba Point	2 1/2 miles-SW	2/annum	56 – 130	93	2
					183	6
Periphyton[c] (pCi/g)	Big Rock Point Plant		2/annum	71 – 210	140	2
	Nine Mile Point		2/annum	21 – 80	50	2
	Mt. McSauba Point		2/annum	34 – 37	35	2
					75	6
Shore minnows[c] (pCi/g)	Big Rock Point Plant		2/annum	250 – 580	415	2
	Nine Mile Point		2/annum	15 – 19	17	2
	Mt. McSauba Point		2/annum	6.3 – 15	11	2
					148	6
Crayfish[c] (pCi/g)	Big Rock Point Plant		2/annum	400 –1,050	725	2
	Nine Mile Point		2/annum	14 – 22	18	2
	Mt. McSauba Point		2/annum	18.5 – 25	22	2
					255	6

[a] Data from Michigan Department of Public Health.
[b] Data from Consumers Power Company surveillance program.
[c] Data from Michigan Water Resources Commission.
ND, nondetectable.

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Table 4. Radionuclide concentrations in water, Big Rock[a]

Sample	Radioactivity (pCi/liter)				
	^{134}Cs	^{137}Cs	^{95}Zr	^{65}Zn	^{60}Co
In channel before release:[b]					
Filter	0.01	<0.01	<0.005	0.14	<0.005
Cation resin	.032	.048	.005	< .05	< .05
In channel during release:[c]					
Filter	5.0	17.0	.24	33.0	1.1
Cation resin No. 1	16.0	53.0	.1	.43	.04
Cation resin No. 2	26.0	82.0	<.1	<.05	<.05
1/4 mile off channel during release:[d]					
Filter	.30	.87	.01	1.3	.05
Cation resin	.55	1.8	.01	.09	<.005

[a] Data from Argonne National Laboratory study.
[b] Sample taken October 18, 1970, the day before a scheduled release.
[c] Sample taken next day, about halfway through an 8-hour release.
[d] Collected about 1 hour later, 1/4 mile directly offshore (discharge still in progress).

weights. Data are reported on a dry weight basis (table 5).

Concentration values for the five radionuclides reported in water, plus potassium, were determined in crayfish, water snails, the aquatic macrophytes *Potamogeton* sp. (pondweed) and *Ranunculus* sp. (a herbaceous plant), the green algae *Chara* sp., *Cladophora* sp., and *Periphyton*.

As expected, all species showed marked decreases in concentration with increasing distance from the discharge point. The rate of decline in concentration was more rapid westward of the outfall than to the east of the outfall. The approximately constant cesium-137/cesium-134 ratio indicates an approximately equal cesium input from the plant and from fallout, at least within a few miles.

Sediments The difficulty of finding sandy patches on the generally rocky bottom made the 1970 lake bottom sampling program spotty. A number of samples were taken at various distances directly offshore from the discharge channel, as well as along the beach in both directions from the plant. In general, the samples consisted of sand and gravel mixtures. After air drying, the samples were sifted and the fraction passing through a No. 30 U.S. Standard sieve (0.595-mm opening) was gamma counted. As can be seen from the data in table 6, the wide variations among samples

Table 5. Radioactivity concentrations in near-shore organisms, Big Rock[a]

Sample	Feet from outfall	^{134}Cs (pCi/g)	^{137}Cs (pCi/g)	^{95}Zr (pCi/g)	^{65}Zn (pCi/g)	^{60}Co (pCi/g)	K (g/kg)	$^{137}Cs/^{134}Cs$
Crayfish	14,000 west	0.25	1.4	<0.4	3.8	<0.2	12	5.6
	4,000 "	.57	1.9	< .4	12.4	.6	15	3.3
	2,500 "	.73	2.2	.2	15.1	.73	11	3.0
	<500	4.5	15	1.7	118	2.32		3.3
	Outfall	10.1	54	3.8	620	17.4		5.3
	Outfall	7.4	35	1.6	365	6.95		4.7
	3,000 east	.73	3.8	.14	51	.23		5.2
	5,000 "	.58	3.4	< .4	61	.5	11	5.9
	14,000 "	.35	1.9	.52	15.6	.14	16	5.4
Snails	Outfall	6.37	25.8	2.3	184	13.8	9	4.0
	1,500 east	.80	4.92	.5	47	6.28		6.1
Potamogeton sp	3,000 west	< .1	.18	3.8	6.6	.59	13	>2
	2,500 "	.32	.43	3.4	16.3	.40	14	1.3
	1,500 "	.45	.50	3.4	23.1	.29	13	1.1
	500 "	< .2	.63	2.6	20.2	.20	<10	>3
	500 east	3.1	6.3	4.2	285	15.6	14	2.0
	1,500 "	< .5	1.8	3.2	152	2.95	18	>3
	3,000 "	.47	1.0	3.2	66	2.08	19	2.1
	4,000 "	.49	.77	2.4	46	1.94	16	1.6
Ranunculus sp	3,000 east	1.6	4.6	.6	266	2.14	11	2.9
	4,000 "	.6	2.6	< .4	177	3.70	30	4.3
Chara sp	1,500 east	1.8	2.9	<2	178	13.7	30	1.6
Cladophora sp	4,000 west	.4	1.6	30.8	4.4	.22	<30	4.0
	3,000 "	< .15	1.7	19.2	2.9	.16	86	>11
	2,000 "	2.1	7.1	20	100	3.9	50	3.4
	<500 east	15.2	39.4	35.2	344	23.0	59	2.6
	500 "	4.3	16.8	15.8	179	6.9	38	3.9
	1,000 "	1.7	6.3	10.2	58	1.7	43	3.7
	1,500 "	1.0	4.1	14.8	47	1.2	49	4.1
	8,000 "	1.3	3.5	27.2	11.0	.64	57	2.7
Periphyton	14,000 west	0.43	1.79	1.4	1.9	.05	58	4.2
	<500	38.4	86.5	17.9	1,980	124	3	2.3
	14,000 east	1.6	3.4	8.1	22.1	.77	5	2.1

[a] Data from Argonne National Laboratory Study. All weights are dry weights.

Table 6. Radioactivity in bottom sands, Big Rock[a]

Distance from outfall (feet)	Distance offshore (feet)	^{134}Cs (pCi/g)	^{137}Cs (pCi/g)	^{95}Zr (pCi/g)	^{65}Zn (pCi/g)	^{60}Co (pCi/g)	^{40}K (pCi/g)	^{137}Cs/^{134}Cs
20,000 west	2,000	0.014	0.20	0.006	0.01	0.014	11	14
4,000 west	<200	.065	.57	.03	.20	.026	7	9
3,000 west	<100	.033	.39	.008	.05	.010	7	12
At outfall	100	2.15	6.34	< .2	20.1	2.60	7	2.9
At outfall	100	1.58	5.60	.1	15.3	3.22	11	3.3
At outfall	100	.57	1.97	.03	2.8	.36	9	3.5
At outfall	200	3.32	10.3	.3	61.4	6.75	8	3.1
At outfall	500	.63	2.79	< .1	4.8	.86	7	4.4
At outfall	500	.68	2.66	< .1	3.1	.51	5	3.9
At outfall	2,000	.40	1.57	.2	11.2	2.46	13	3.9
1,500 east	<100	.35	2.31	.12	9.3	.97	7	6.6
3,000 east	<100	.66	2.68	.09	3.9	.45	10	4.1
4,000 east	<100	.10	.77	< .02	.63	.09	7	7.7
5,000 east	<100	.08	.68	.06	.15	.07	8	8.5
10,000 east	<200	.11	.56	< .05	.46	.11	9	5.1

[a] Data from Argonne National Laboratory study. All weights are dry weights.

from the discharge channel points up the difficulty of obtaining representative grab bottom samples at this site.

Fish Since fish are potentially a human food source, they must be considered when studying the radiological health aspects of releases from nuclear facilities. It is desirable to take large numbers of samples for study, in view of the mobility of the organisms and the variability of the sources of radioactivity. The 1970 samples taken by Argonne (table 7) are composites of several whole fish, mostly below edible size, taken from the discharge channel. From these samples it would appear that the fish studied have lower radionuclide concentrations than do other biota in the vicinity. In addition, analyses indicated that the zinc-65 concentration in the edible portions is about one-fourth that of the whole fish.[3]

Discharges Operator reports on liquid and gaseous discharges during 1970 are summarized in table 8. A total of 4.68 curies, excluding tritium, of liquid wastes and 277,500 curies of gaseous wastes were discharged. All batches of liquid discharges were identified by isotopic composition; approximately 45 percent of the activity was due to zinc-65. The remainder was composed mainly of cesium-134, cesium-137 and iodine-131.

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[3] D. M. Nelson, personal communication.

Table 7. Radioactivity in fish, Big Rock[a]

Sample	Location	^{134}Cs (pCi/g)	^{137}Cs (pCi/g)	^{95}Zr (pCi/g)	^{65}Zn (pCi/g)	^{60}Co (pCi/g)	^{40}K (g/kg)	^{137}Cs/^{134}Cs
Bluegill: No. 1	Outfall	1.05	3.95	0.3	34.5	1.21	10	3.8
No. 2	Outfall	1.03	5.44	< .05	15.4	.65	12	5.3
No. 3	Outfall	2.23	8.19	.1	86	.89	10	3.7
No. 4	Outfall	1.59	6.27	.2	51	.05	13	3.9
Alewife: No. 1	Outfall	.92	5.71	< .15	138	1.1	13	6.2
No. 2	Outfall	.19	.91	< .05	4.43	.10	11	4.8
No. 3	Outfall	< .1	.67	< .05	.86	.16	11	>7
Bass: No. 1	Outfall	.22	2.06	< .06	6.7	.07	14	9.4
No. 2	Outfall	.30	3.19	.1	6.0	.6	14	10.6
No. 3	Outfall	.27	1.77	< .1	1.3	< .06	10	6.6
Sunfish	Outfall	.33	1.06	< .06	4.2	.2	10	3.2
Sucker	Outfall	< .1	1.03	< .05	< .3	< .03	16	>10
Average		0.70	3.4	0.11	29	0.43	12	

[a] Data from the Argonne National Laboratory study. Weights expressed are dry weight, which is 20 to 25 percent of wet weight values.

Table 8. Gross discharge of radioactivity from Big Rock Point nuclear plant, 1970[a]

Month (1970)	Gaseous discharges (Ci)	Liquid discharges		
		Batches	Gallons	Activity (mCi)[b]
January	40,900	3	14,885	92.9
February	19,500	5	24,035	56.9
March	79	11	54,795	785.0
April	3,490	3	13,660	98.6
May	4,060	4	18,850	199.2
June	3,870	5	25,580	296.2
July	5,320	4	19,750	330.0
August	7,850	6	28,005	1,222.4
September	22,200	4	19,750	207.2
October	41,900	7	31,800	379.4
November	48,200	3	15,685	786.0
December	80,200	4	18,175	228.1
Total	277,569	59	284,970	4,681.9

[a] Data from Consumers Power Company operating reports.
[b] Excluding tritium.

Enrico Fermi-1

This facility is a liquid sodium-cooled fast breeder reactor. Its design characteristics include a stack of 200 feet high and a stack exhaust rate of 1,390,000 cubic-feet-per-minute. It has absolute filters for particulates, no installation for iodine treatment, and a holdup capacity for gaseous radioactive wastes of up to 4 months. Liquid wastes are released into Lake Erie on a controlled basis.

During operations from August 1963 until shutdown in 1966, radioactive gaseous waste discharges ranged from 7×10^{-4} to 1.4×10^{-2} curies per year. The latter represents 2×10^{-3} percent of the concentration limit of 2×10^{-6} μCi/cm^3 in the discharge stack.

During shutdown, gaseous radioactive waste discharges were not measurably different from normal background. Radioactivity in liquid waste discharges, on the other hand, could be detected throughout the shutdown period. This is to be expected in consequence of continuing decontamination operations. For 1969—the most recent full year of shutdown—a total of 63,700 gallons, containing 0.053 curies, was discharged. This represented 0.22 percent of the discharge limit. No tritium discharge values were reported. Activity during the first month of 1970 showed a decline to a rate of about one-third of the 1969 values. Full power tests began late in 1970.

Data on discharges for 1970, supplied by the facility operators, indicate that discharges were low. Gaseous waste discharges from the stack were below detectable levels. Liquid discharges amounted to a total of 40.4 millicuries. A sample of Lake Erie water taken north of the plant on October 22, 1969, had a tritium concentration of 1 ± 0.7 nanocurie per liter (*3*). Two additional samples collected on that date had concentrations below the detectable level of 0.7 nCi/liter. A surface water sample from Lake Erie in the vicinity of Lagoona Beach was taken on September 12, 1970, for tritium analysis. Tritium activity was found to be below the detectable limit of 0.6 nanocurie per liter.

Surveillance around the Fermi reactor is conducted by the State of Michigan and the Detroit Edison Company. Analytical data for gross beta radioactivity in environmental samples for 1970 are given in table 9. The table includes corresponding data for Lansing, which serves as a control station.

Palisades Nuclear Power Station

The construction permit for this plant was issued in March 1967. Although commercial operation was planned for 1970, authorization for fuel loading and low power (not to exceed 1 megawatt thermal) testing was not granted by the Atomic Energy Commission until March 1971. The Palisades plant design provides for holdup of radioactive gaseous waste for at least 30 days, allowing the decay of short-lived radionuclides. The plant lies within the drainage basin of Brandywine Creek, which flows into Lake Michigan.

Environmental surveillance activities in the vicinity of this plant for 1970 serve as part of the preoperational surveillance program. Environmental surveillance data for the area are shown in tables 10 and 11. Since the Palisades plant was not operational during 1970, these data may be considered background levels.

Lake Michigan survey

Lake Michigan surveillance for environmental radioactivity was performed for the period July 1969–June 1970 by the University of

Table 9. Gross beta radioactivity in environmental samples, Enrico Fermi–1 reactor, 1970

Sample type	Location	Distance from Enrico Fermi Plant	Frequency of collection	Radioactivity		Number of samples
				Range	Mean	
Air particulate:[a] (pCi/m^3)	Carleton	7 miles-NW	Weekly	0.053– 0.54	0.225	52
	Monroe	6 miles-WSW		.069– .56	.216	43
	Rockwood	7 miles-NNE		.054– .75	.259	33
	Reactor site			.061– .70	.235	47
	Lansing[b]	85 miles-NW		.035– .66	.206	51
					0.234	177
Precipitation:[a] (pCi/liter)	Carleton		Weekly	9 – 330	80	27
	Monroe			12 – 190	58	27
	Rockwood			12 – 605	85	29
	Reactor site			17 – 470	75	26
	Lansing[b]			16 – 920	130	29
					86	109
Deposition from precipitation:[a] (pCi/m^2-day)	Carleton		Weekly	25 – 580	290	27
	Monroe			17 – 480	138	27
	Rockwood			15 – 400	133	29
	Reactor site			40 – 310	139	26
	Lansing[b]			22 – 1,300	291	29
					175	109
Air particulate:[c] (pCi/m^3)	5 locations on site		Weekly	.076– .914	.275	260
	Monroe	8 miles-WSW	Weekly	.062– .913	.27	52
	Carleton	10 miles-NW		.037– .715	.25	52
	Flat Rock	9 miles-N		.056– .827	.27	52
	Trenton	14 miles-NNE		.069– .786	.26	52
	Ann Arbor	85 miles-NW		.055– .914	.27	52
						260
Surface water:[c] (pCi/liter)	Reactor channel		Weekly grab	3.1 – 29	8.0	52
	Swan Creek			3.3 – 33	10	52
	Lake Erie			2.6 – 49	7.2	52
	Monroe-Lake Erie		Weekly daily composite	3.8 – 8.3	5.1	52
	Flat Rock-Huron River			3.6 – 18.9	7.1	52
	Huron River:					
	Ypsilanti				12	
	Flat Rock			[d]ND–12	10	
	Rockwood				ND	
	Estral Branch			ND–10	9	
	Lake Erie-Monroe			ND–12	10	
	Raisin River: Monroe			ND–18	12	
	Dundee			ND	ND	
	Swan Creek-Estral Branch			ND	ND	
	Dundee-Raisin River			4.7 – 27.7	8.0	52
	Toledo-Lake Erie			3.2 – 18.7	5.5	52
	Detroit-Lake St. Clair			2.7 – 12.1	4.3	52
	Allen Park-Detroit River			2.6 – 7.9	4.3	52
	Ann Arbor-Huron			1.7 – 16.6	5.8	52
	Colchester-Lake Erie			2.7 – 26.2	6.4	52
					5.8	312
Drinking water (pCi/liter)	Flat Rock			3.4 – 6.4	5.0	
Deposition:[c] (pCi/m^2-day)	5 locations on site		4 weeks	32 – 585	242	65
	Monroe	8 miles-WSW	4 weeks	47 – 655	239	13
	Carleton	10 miles-NW		37 – 816	265	13
	Flat Rock	9 miles-N		47 – 571	228	13
	Trenton	14 miles-NNE		31 – 806	289	13
	Harrow			44 – 672	228	13
					249	65
Milk:[c] (reactor group-pCi/liter)	Monroe		4 weeks	603 – 1,640	1,080	13
	Newport			796 – 1,520	1,070	13
					1,075	26
Milk:[c] (background group-pCi/liter)	McCalla Ypsilanti		4 weeks	645 – 1,570	1,060	13
	Bolgos Ann Arbor			541 – 1,450	1,060	13
					1,060	26

See footnotes at end of table.

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Table 9. Gross beta radioactivity in environmental samples, Enrico Fermi–1 reactor, 1970—continued

Sample type	Location	Distance from Enrico Fermi Plant	Frequency of collection	Radioactivity		Number of samples
				Range	Mean	
Fish:[c] (pCi/g-wet)						
Perch	Reactor area		Quarterly	0.96 – 5.01	2.42	9
	Buffalo area			1.28 – 3.06	2.13	12
					2.28	21
Bass	Reactor area		Varies	1.24 – 2.37	1.69	9
	Buffalo area			2.16 – 2.83	2.42	3
					2.06	12
Smelt	Buffalo area		Varies	1.35 – 1.81	1.59	6
Shad	Reactor area		Varies	1.69 – 2.10	1.88	3
Whitefish	Buffalo area		Varies	2.69 – 2.97	2.81	3

[a] Data from Michigan Department of Public Health.
[b] Lansing, a control surveillance station, is not included in calculation of mean activity or sample count for surveillance stations around Enrico Fermi.
[c] Data from Detroit Edison Company. The data covers the period December 24, 1969 to November 25, 1970.
[d] ND, nondetectable for gross beta = <9 pCi/liter.

Table 10. Gross beta radioactivity in environmental samples, Palisades reactor, 1970[a]

Sample type	Location	Distance from Palisades Plant	Frequency of collection	Radioactivity		Number of samples
				Range	Mean	
Air particulate: (pCi/m³)	South Haven	4 1/2 miles NNE	Weekly	0.059– 0.92	0.264	41
	Rendall service station	4 miles SSW		.08 – .74	.311	34
	Covert	4 miles SE		.065– .64	.248	41
	Reactor site			.071- .63	.244	42
					0.267	158
Precipitation: (pCi/liter)	South Haven		Weekly	12 – 650	144	29
	Rendall service station			16 – 610	149	29
	Covert			17 – 700	138	29
	Reactor site			18 – 730	143	30
					144	117
Deposition from precipitation: (pCi/m²-day)	South Haven		Weekly	24 –1,400	336	29
	Rendall service station			42 –1,100	317	29
	Covert			12 –1,300	326	29
	Reactor site			15 – 990	267	30
					312	117
Drinking water: (pCi/liter)	South Haven			3.1 – 5.1	3.4	
	St. Joseph			2.4 – 4.3	3.5	
	Benton Harbor			2.7 – 4.2	3.4	
Surface water: (pCi/liter)	Rogers Creek-Covert			ND-9	9	
	Black River-South Haven			ND	ND	
	Brandywine Creek-South Haven			ND-13	10	
	Lake Michigan-Benton Harbor			ND	ND	
	Lake Michigan-South Haven			ND-24	12	
	Lake Michigan-Bridgman			—	ND	
	St. Joseph River-St. Joseph			ND-10	9	
Plankton: (pCi/g)	Palisades Plant		1/annum		24.5	1
	Thirteenth Avenue	3 3/4 miles NNE			12.5	1
	Covert Park	4 3/4 miles SSE			24.5	1
					20.5	3
Shore minnows: (pCi/g)	Palisades Plant		1/annum		12.0	1
	Thirteenth Avenue				32.0	1
	Covert Park				13.0	1
					19.0	3
Filamentous algae: (pCi/g)	Palisades Plant		1/annum		120	1
	Thirteenth Avenue				30	1
					75	2

[a] Data from Michigan Department of Public Health.

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Table 11. Preoperational surveillance data from Palisades nuclear power station, 1970[a]

Sample type	Type of measurement	Number of samples	Radioactivity	
			Mean	Range
Lake water: (pCi/liter)	Gross β	8	7.5	5 – 13
	Tritium	8	414	310 –600
Fish: (pCi/g)	Gross β	5	2.7	1.2 – 4.4
	Gross γ	5	.15	.04– 0.31
	^{90}Sr	5	.05	.02– .11
	^{137}Cs	5	.13	.08– .2
Milk: (pCi/liter)	^{137}Cs	16	1.9	.52– 7.0
	^{90}Sr	16	1.7	.87– 5.4
	^{3}H	4	[b]1.9	[b].81– 3.4
Air particulates: (pCi/m^3)	Gross β	35	.13	.04– .34
Fruits and berries: (pCi/g)	Gross β	15	2.54	.67– 2.7
	Gross γ	13	.20	.10– .28
Aquatic vegetation: (pCi/g)	Gross β	2	6	4 – 8
	Gross γ	2	1.7	1.4 – 2.1

[a] Data from Palisades Nuclear Power Station preoperational environmental radiation survey program summary report, May 28, 1971 by Consumers Power Company.
[b] Concentration, nCi/liter.

Table 12. Environmental radiation surveillance, Lake Michigan, July 1969–June 1970[a]

Sample type	Number of locations	Number of samples averaged	Analyses		Radioactivity		Average[b]
			Type	MDL	Minimum	Maximum	
Water	21	49	Zinc-65	8 pCi/liter	ND	32 pCi/liter	2.1 pCi/liter
			Cesium-137	3.5 pCi/liter	ND	9.5 pCi/liter	.63 pCi/liter
			Carbon-14				.2 pCi/liter
			Potassium-40				1.1 pCi/liter
			Radium-226				.03 pCi/liter
			Lead-210				.003 pCi/liter
			Tritium				560 pCi/liter
			Gross alpha				3.0 pCi/liter
			Gross beta (exclusive of ^{3}H)		1.3 pCi/liter	5.9 pCi/liter	[c]3.8 pCi/liter
Sediment: (1970)	43	53	Cesium-137	.1 pCi/g	ND	8.1 pCi/g	1.4 pCi/g
			Radium-226	(d)	0.4 pCi/g	4.6 pCi/g	1.6 pCi/g
			Potassium-40	(d)	5.0 pCi/g	30.0 pCi/g	15.0 pCi/g
Zooplankton: (ash weight)	21	59	Zinc-65	2.2 pCi/g	ND	95.5 pCi/g	2.3 pCi/g
			Cesium-137	1.0 pCi/g	ND	95.7 pCi/g	4.75 pCi/g
			Gross beta		5.2 pCi/g	162.2 pCi/g	58.2 pCi/g
Zooplankton: (wet weight)	21	59	Zinc-65	2.2 pCi/g	ND	1.2 pCi/g	.09 pCi/g
			Cesium-137	1.0 pCi/g	ND	3.2 pCi/g	.054 pCi/g
			Gross beta		.1 pCi/g	2.9 pCi/g	.725 pCi/g
Phytoplankton: (ash weight)	21	59	Zinc-65	2.2 pCi/g	ND	566.1 pCi/g	31.6 pCi/g
			Cesium-137	1.0 pCi/g	ND	6.4 pCi/g	.33 pCi/g
			Gross beta		16.1 pCi/g	119.1 pCi/g	36.9 pCi/g
Phytoplankton: (wet weight)	21	59	Zinc-65	2.2 pCi/g	ND	5.9 pCi/g	.96 pCi/g
			Cesium-137	1.0 pCi/g	ND	.7 pCi/g	.038 pCi/g
			Gross beta		.5 pCi/g	10.4 pCi/g	2.45 pCi/g
Benthos: (ash weight)	22	58	Zinc-65	2.2 pCi/g	ND	108.9 pCi/g	29.4 pCi/g
			Cesium-137	1.0 pCi/g	ND	20.2 pCi/g	2.86 pCi/g
			Gross beta		19.4 pCi/g	258.5 pCi/g	108.9 pCi/g
Benthos: (wet weight)	22	58	Zinc-65	2.2 pCi/g	ND	27.8 pCi/g	.89 pCi/g
			Cesium-137	1.0 pCi/g	ND	.5 pCi/g	.079 pCi/g
			Gross beta		.1 pCi/g	39.7 pCi/g	3.77 pCi/g
Fish:[e] (ash weight)	7	7	Zinc-65	2.2 pCi/g	ND	31.7 pCi/g	12.8 pCi/g
			Cesium-137	1.0 pCi/g	ND	29.9 pCi/g	8.66 pCi/g
			Gross beta		81.9 pCi/g	107.3 pCi/g	93.8 pCi/g
Fish: (wet weight)	7	7	Zinc-65	2.2 pCi/g	ND	1.0 pCi/g	.42 pCi/g
			Cesium-137	1.0 pCi/g	ND	.92 pCi/g	.36 pCi/g

[a] Data from University of Michigan study.
[b] Mean values based on <MDL (minimum detectable level) taken as zero. Averages for long-lived radionuclides would consequently tend to be low.
[c] It is considered that less than 2 pCi/liter of gross beta activity in Lake Michigan water is attributable to radioactivity of natural origin (4).
[d] All radium-226 and potassium-40 levels were significant; hence determination of MDL was unnecessary.
[e] A sample of perch (edible flesh, wet weight) taken at Big Rock Point showed the following values: cesium-137, 0.92 pCi/g; zinc-65, 0.24 pCi/g.
ND, below detectable limits (<MDL), corrected for decay back to June 15, 1969.

Michigan under a contract with a consortium of utility companies. Media surveyed were water, bottom sediment, plankton, benthic organisms, and fish (*4*). Samples were taken at grid locations along five tracks approximately equally spaced over the lake. Data developed in the course of this survey are presented in table 12 and are not inconsistent with the Argonne data shown in table 6.

Inspection of the values for samples taken from areas of the lake near the Big Rock Point Plant revealed no substantial deviations from the averages for the lake as a whole. Accordingly, a separate tabulation has not been provided for that area. This is in contrast to the data obtained by Argonne and presented in tables 5, 6, and 7. Argonne performed intensive sampling within 3 miles of the site. The closest sample point used for the University of Michigan study was 1 mile from the site of Big Rock Point discharges.

Summary of surveillance activities

Environmental radiation from various sources and media have been measured in the State of Michigan. A summary of available data is presented in table 13. It has not been possible to acquire all the specific data that may be required to construct an accurate estimate of the radiation exposure of the population of Michigan, or any given portion of this population. Nevertheless, some broad perspectives can be gained, particularly with respect to the major sources of exposure.

It may be noted that the gross beta radioactivity in air is of the same general magnitude for the vicinity of the Big Rock Point plant as for the vicinity of the Palisades plant, a control site at a distance from any operating reactor. Also, data for precipitation do not indicate any need to consider this source as applicable to special problems related to existing nuclear power operations.

Although radioactivity in Lake Michigan water (table 12) may not reflect the true situation with respect to the public drinking water supplies, the gross beta radioactivity is well within the PHS drinking water standard of 1,000 pCi/liter, taking into account the small amounts of radium and strontium-90 present.

The 1970 average values for strontium-90 and cesium-137 in milk are close to those for the EPA Pasteurized Milk Network stations and State stations. A listing of the individual stations in the State would show variations among the stations at least equal in magnitude to the deviation of the State average from the Pasteurized Milk Network average, as may be seen in table 14 for the 12-month State average.

Although the Charlevoix area, which is near the Big Rock Point plant, showed somewhat higher values than the State average, no conclusion can be drawn from this finding. Marquette, which is on Lake Superior and far removed from any nuclear power plant, showed even higher values.

In the absence of a diet surveillance program within the State, it may be of interest to consider data from the institutional diet sampling program conducted jointly by EPA and the Food and Drug Administration. Cleveland, Ohio, the sampling location nearest to Michigan, showed 1970 dietary intake values for strontium-90 and cesium-137 of 11 and 10 pCi per day, respectively (*8*). This compares with the national network averages of 10 and 11 pCi per day for strontium-90 and cesium-137, respectively. Since the daily intake for strontium-90 and cesium-137 is approximately equal to that contained in a liter of milk, it seems reasonable to assume, for purposes of dietary intake calculations, that if we take the value for intake of a liter of milk per day, we can approximate the average daily total dietary intake of these radionuclides.

The data for background terrestrial radiation dose in table 13 were derived by taking measurements at some distance from manmade structures (*7*). The effects of proximity of manmade structures and variations in indoor environments are not considered in the tabulation. The values for terrestrial and cosmic radiation dose agree with those published by Solon et al. (*9*) and by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (*10*) for cosmic radiation dose. Both the State of Michigan and Consumers Power Company report no detectable gamma dose above background from their TLD

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Table 13. Michigan surveillance programs

Media sampled	Location (number of sites)	Collection frequency	Number of samples	Type of analyses	Radioactivity	
					Mean	Range
Air:	(14)	Weekly		Gross beta		
(reactor-oriented)	Big Rock (5)		250		0.252	0.059– 0.94
(pCi/m^3)	Fermi (4)		177		.234	.053– .75
	Palisades (4)		158		.267	.059– .92
	Lansing (1)[a]		51		.206	.035– .66
Precipitation:	(14)	Weekly		Gross beta		
(reactor-oriented)	Big Rock (5)		91		32.8	.17 -130
(pCi/liter)	Fermi (4)		109		85.6	9.1 -605
	Palisades (4)		117		144.0	12.0 -730
	Lansing (1)[a]		29		130.0	16.0 -920
Deposition:	(14)	Weekly		Gross beta		
(reactor-oriented)	Big Rock (5)		91		8.65	.15 - 28
(fCi/m^2-day)	Fermi (4)		109		17.5	1.5 - 58
	Palisades (4)		117		31.2	1.2 -140
	Lansing (1)[a]		29		29.1	2.2 -130
Water: (pCi/liter)						
Lake Michigan	See table 11 for data other than strontium-90					
	Various depths		9	Strontium-90[b]	.6	
Drinking water: (pCi/liter)	Throughout State	Quarterly or semiannually	107	Gross beta	3.1	<.94 - 8.4
Surface water: (pCi/liter)	Throughout State	Quarterly or semiannually	137	Gross beta	<8.2	<8.2 - 28
Milk: (ref. 6)		Monthly				
PMN	(2)			Strontium-90	9.2	
State network	(8)			Cesium-137	11.0	
Natural background terrestrial: (ref. 7)	(23)			Gamma	7.8 μrad/h 70 mrad/a	6.6 – 9.2 μrad/h
Cosmic radiation: (based on average inhabitant elevation = 600 feet)	Statewide				4.1 μrad/h 36 mrad/a	

[a] Lansing: control surveillance station.
[b] Extrapolated from reference (*5*).

Table 14. 12-month average of radionuclide concentrations in milk, 1970

Station	Concentrations (pCi/liter)	
	Strontium-90	Cesium-137
Detroit[a]	9	9
Grand Rapids[a]	9	12
Bay City	7	11
Charlevoix[b]	13	16
Detroit	8	8
Grand Rapids	9	8
Lansing	9	14
Marquette	14	23
Monroe	6	3
South Haven	8	6
Average	9	11

[a] EPA Pasteurized Milk Network station.
[b] Area of Big Rock Point Plant. Other stations are part of Michigan Department of Health network.

and film badge readings at offsite locations near Big Rock Point nuclear power station.

In addition to the foregoing sources of radiation exposure, the State of Michigan reported, for fiscal 1970, three operable nuclear reactors (non-power); 465 licenses for by-product, source, and special nuclear materials; 130 registered facilities for the use of radium or radon; and 30 particle accelerators (*11*). The State also has regulatory legislation with respect to x-ray machines, of which there were 4,078 dental, 4,330 medical (including 265 therapeutic), and 170 industrial x-ray machines registered (*11*).

Dose assessment of Michigan population

Table 15 presents a summary of estimated annual radiation doses to the population from all identified sources. Included is the special case of doses to the population in the vicinity of

Big Rock Point. Doses from the lesser contributory sources are included for perspective. Totals given as ranges are rounded to two significant figures, as warranted by the limitations of the estimates.

The data for external background gamma radiation (*7*) are not intended to represent average radiation levels for exposure of the State's population, since the areas surveyed were not randomly selected, nor were they spaced with the idea of developing contour lines. Nevertheless, the data are made from determinations within the State, and may be considered as providing a reasonable estimate. Of the reactor sites, only the South Haven (Palisades) area was monitored. The average background gamma radiation level at this location was 7.3 μR/hr, which was below the average for the State measurements.

The value given for cosmic radiation is probably on the low side, since it assumes an elevation of 600 feet above sea level. Lake Michigan itself is at an elevation of 581 feet, while the average elevation of the State is 900 feet (*14*). Reactor sites on Lake Michigan and Lake Erie (elevation 572 feet) would probably be at altitudes of close to 600 feet.

The genetically significant dose (GSD) of 55 mrem/a from medical diagnostic x-rays was taken from the 1964 national survey (*15*). The radiation dose figures from occupational and miscellaneous sources are admittedly out-of-date, and may be lower in Michigan than those given in table 15, particularly the value for GSD from occupational exposure. Factors that are expected to contribute to occupational exposure are the growth in nuclear medical procedures and research, growth in industrial use of x-rays, and radionuclides in materials analysis and processing. However, industrial use of ionizing radiation in Michigan has declined approximately 30 percent from 1965 to 1970.[4]

Dose related to nuclear power operations

As mentioned, Big Rock Point is the only nuclear power facility in Michigan which operated during the entire year of 1970. It, therefore, represents the source of maximum population dose resulting from nuclear power facility effluents. Because of background radiation, the contribution of radionuclides from the reactor released to the environment cannot be precisely distinguished. Nevertheless, some idea of the magnitude of population dose from this source may be obtained by using one of the following approaches.

Dose from external radiation A special study (*16*) performed around the Dresden Nuclear Power Station in Illinois—a facility with gaseous effluents similar to those at Big Rock Point—determined that the only measurable population dose attributable to plant effluents, was due to external radiation from noble gases discharged to the atmosphere. These measurements indicated that the maximum dose to an individual member of the public in the vicinity of the Dresden plant would be in the range of 5 to 15 millirem per year.

Gamertsfelder (*17*) has made calculations of population dose around operating nuclear facilities based on discharges and environmental conditions. His calculations indicate a dose from all exposure pathways of 18 millirem per year at the boundary of the Dresden plant during 1969. This agrees with the values based on the 1968 special study (*16*) mentioned above, when the gaseous discharges were one-third as high as in 1969. Such agreement tends to support the accuracy of the calculated dose. Gamertsfelder's calculations of population dose from Big Rock Point waste discharges indicate a maximum dose of 3.25 millirem per year at the plant boundary, and an average dose within a 50-mile radius from the plant of 0.065 millirem per year.[5] One could not expect to measure this level of population exposure in the environment in the presence of the other sources of higher exposure. This is partially confirmed by the data (table 13) for air and precipitation which show no higher levels near Big Rock Point than at other locations.

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[4] Personal communication from Mr. D. E. Van Farowe, chief, Division of Radiological Health, State of Michigan Department of Public Health.

[5] R. W. Sunderman, health physicist, Consumers Power Company (personal communication) points out that these dose calculations are high by a factor of 2.4.

Table 15. Estimated annual radiation doses[a] to general population, Michigan

Source of radiation	Dose (mrem/a)	Remarks
Natural radiation (external):		
Terrestrial gamma rays	60 – 85	Reference (7)
Cosmic rays	35 – 50	Based on UNSCEAR (*10*) and special studies[b]
Natural radiation (internal sources):		
Potassium-40	17	Special studies[b]
Carbon-14	.7	To gonads; 1.6 to bone marrow (10)
Radium-226, radium-228 and progeny	.6	To gonads; 0.7 to bone marrow (10)
Subtotal (rounded)	113 – 153	
Residual fallout from nuclear tests[c] as source:		
Cesium-137	1.2	Based on 0.3 mrad following intake of 1 nanocurie from 360 liters of milk/a
Strontium-90	.25	To bone marrow, based on FRC Report No. 2 (*12*), assuming average intake of 1 g calcium/day
Carbon-14	.7	Computed from dose commitment data in UNSCEAR (*10*)
Tritium	.001	
Subtotal	2.0	
Medical radiation x rays:		
X rays, diagnostic	55	Genetically significant dose (GSD) (see text)
Radiation, therapeutic x and gamma rays	5	GSD, estimated[d]
Radiopharmaceuticals, therapeutic	.6	GSD, estimated[d]
diagnostic	.6	
Occupational	~1	Average dose to U.S. population[b]
Other (luminous dials, TV, etc.)	2	GSD, estimated (*13*)
Subtotal	64	
Total (rounded)	180 – 220	
Residents, Big Rock Point vicinity:		
External	.065	Average, 50-mile radius from plant
Internal (ingestion)	~1	(See text)

[a] Dose to gonads and other soft tissues, except where otherwise stipulated.

[b] Special Studies Group, Division of Criteria and Standards, Office of Radiation Programs, EPA. Estimates of ionizing radiation doses in the United States, 1960–2000 (in press).

[c] Strontium-89, iodine-131, and other short-lived radionuclides are considered to have decayed to zero.

[d] Dr. B. Shleien, personal communication, based on data for 1966.

Dose from ingested radionuclides A somewhat oblique approach to dietary intake of radioactivity is attempted to provide some idea of the possible contribution of diet to dose. In the absence of data on radioactivity in and consumption of local game and other animals, or of vegetable produce or other local foods, an admittedly high intake of fish taken in the vicinity of the plant is assumed. An intake of 100 grams per day of fish taken from the vicinity of the outfall of the Big Rock Point plant (average values from table 7 divided by 4 to compensate for dry weight) is assumed in our calculations. The formula used is adapted from the method of Weaver (*18*), and is based on a summation of intakes of each radionuclide as a fraction of the Radiation Protection Guide (RPG) for a member of the general population. The formula is:

$$\frac{I_A}{\text{guide A}} + \frac{I_B}{\text{guide B}} + \frac{I_C}{\text{guide C}} \ldots = F_{RPG}$$

where I_A, I_B, I_C, etc., are intakes (pCi/day) of the individual radionuclides, and F_{RPG} is the fraction of the RPG for the sum of the nuclides.

The radionuclides determined in this case are cesium-134, cesium-137, zirconium-95, zinc-65, and cobalt-60. Application of the average values for these nuclides from table 7, adjusted for wet weight concentrations, gives:

$$\frac{17.5}{20{,}000} + \frac{84}{45{,}000} + \frac{2.7}{130{,}000} + \frac{730}{220{,}000} + \frac{11}{110{,}000} = 0.0062^{6}$$

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[6] These calculations do not make allowance for the functional contribution of cesium-137 from fallout. D. M. Nelson (personal communication) indicates that this contribution is about one-half of the total for this radionuclide.

Thus, on the basis of conservative (and probably pessimistic) premises both for consumption and site of capture of the fish, the radioactivity intakes amount to 3.3 millirem per year or less than 1 percent of the radiation protection guide of 500 mrem. If an average annual population consumption of 8 kilograms of fresh fish, as estimated for the United States (*19*), is assumed, the dose would be less than 1 millirem per year.

Discussion

The first report of surveillance activities in the State of Michigan shows that at least one nuclear facility is discharging sufficient radioactive material to be detected in the environment. However, the resulting dose to the population is insignificant in comparison to the dose from other sources. The maximum dose to a hypothetical individual from a nuclear facility's discharges is only a gross estimate. Participation in the National Environmental Radiation Monitoring Program by monitoring agencies in the State and more detailed reporting of discharges by nuclear facility operators as proposed by the Atomic Energy Commission should result in more usable data for dose calculations in the future.

Acknowledgements

Appreciation is expressed to the following for their assistance in supplying data and their constructive suggestions on this report. D. E. Van Farowe, chief, Division of Radiological Health, State of Michigan Department of Health; Professor G. H. Whipple, Department of Environmental and Industrial Health, University of Michigan; R. W. Sinderman, health physicist, Consumers Power Company; and J. Feldes, Detroit Edison Company.

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A Summary of Environmental Radiation Surveillance Activities in Arkansas

Burvie H. Sheets, William H. Oates, Jr., David D. Snellings, Jr., and E. Frank Wilson[1]

This report describes the environmental radiation surveillance program of the Division of Radiological Health, Arkansas State Department of Health. The program has been broken into two general categories: (1) statewide system and (2) source-oriented surveillance activities. There are two nuclear facility sites in Arkansas and extensive surveillance activities are presently being conducted near each site. Some of the data that were collected during 1966 through 1970 are presented.

The State Department of Health was designated the responsible agency within the State of Arkansas for the evaluation and control of radiation hazards by Act 8 of the Second Extraordinary Session of the Arkansas Legislature of 1961. One of the methods used in assessing radiation hazards is a continuing environmental radiation surveillance program. The purpose of this report is to provide a general description of this surveillance program and a summary of data that has been collected for the period 1966 through 1970. The radiation surveillance program in Arkansas can be divided into three categories:

1. State,
2. Southwest Experimental Fast Oxide Reactor (SEFOR), and
3. Arkansas Nuclear One Reactor (AN–1).

The State program was established during 1956 as a result of atmospheric nuclear weapons testing. This program consists of:

1. Monthly analyses of milk samples which are collected from representative processing plants throughout the state,
2. Analyses of precipitation collected at the State Department of Health Building in Little Rock, and
3. Participation in the Radiation Alert Network air sampling program of the Environmental Protection Agency by operating the Little Rock station.

Both the SEFOR and the Arkansas Nuclear One programs are source-oriented surveillance activities. The SEFOR program consists of the collection and analysis of milk and other environmental samples in the offsite environs of the Southwest Experimental Fast Oxide Reactor (SEFOR) located 20 miles southwest of Fayetteville, Ark. The Arkansas Nuclear One (AN–1) program is currently a preoperational project conducted in the vicinity of the construction site for Arkansas Power and Light Company's (AP&L) first nuclear power reactor. This pressurized water reactor (PWR) will be located approximately 6 miles west of Russellville, Ark., on the Dardanelle Reservoir.

Analytical methods

Environmental samples are prepared and analyzed for radioactive materials using gamma scintillation and proportional counting equipment. The objectives of the surveillance programs require both the qualitative and quantitative analysis of radionuclides present. For source-oriented surveillance activities, the radionuclides to be evaluated are specified early in the system planning phase as a portion of the public health evaluation. The necessary equipment and procedures are then established to perform the required identification and measurements.

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[1] Mr. Wilson is the director, Mr. Snellings is the assistant director and Messrs. Oates and Sheets are staff members of the Division of Radiological Health, Arkansas State Department of Health, Little Rock, Ark. 72201.

Total sample analysis is performed by spectral analysis and/or radiochemistry techniques. Gamma spectroscopy is a relatively simple laboratory procedure; however, detailed standardization methods and mathematical analyses are necessary to evaluate the resultant data. Radiochemistry is a more complex and time-consuming method but is necessary for the separation and analysis of non-gamma-emitting radionuclides.

Gamma scintillation methods are used to simultaneously quantitate the following radionuclides:

Cerium–144
Iodine–131
Ruthenium–106
Cesium–137
Zirconium–95
Manganese–54
Thorium–232
Zinc–65
Potassium–40
Barium–140
Bismuth–214

This type analysis, which is routinely performed on those samples listed in tables 1 and 2, involves no radiochemical reduction but is a direct evaluation of the raw sample. Resultant data are then compiled into a series of simultaneous equations which are solved by the matrix method. This method utilizes the photopeak areas of the sample spectrum and involves solving simultaneous equations to correct for the interference of one radionuclide in the peak of another. Computer techniques are used to solve the equations and also correct for the radioactive decay and the detector efficiency for each radionuclide.

Table 1. Environmental surveillance program at the SEFOR nuclear reactor

Type of sample	Relative sampling frequency	Type of analysis
Surface water	Quarterly	Gamma scan, gross alpha and beta
Silt	Quarterly	Gamma scan, gross alpha and beta
Grass	Quarterly	Gamma scan, gross alpha and beta
Soil	Quarterly	Gamma scan, gross alpha and beta
Milk	Monthly	Gamma scan
Air	Biweekly	Gamma scan, gross beta

Radiostrontium is chemically extracted from milk samples under laboratory conditions using the methods described by Porter et al. (*1*). The strontium is then analyzed in a low-background beta counter. After a suitable daughter ingrowth period and subsequent measurements, final calculations are performed to determine the quantity of radiostrontium in the milk.

Table 2. Preoperational environmental surveillance program at Arkansas Nuclear One

Type of sample	Relative sampling frequency	Type of analysis
Surface water	Semiannually	Gamma scan, gross alpha and beta, tritium
Silt	Semiannually	Gamma scan, gross alpha and beta
Grass	Semiannually	Gamma scan, gross alpha and beta
Soil	Semiannually	Gamma scan, gross alpha and beta
Aquatic biota	Semiannually	Gamma scan, gross beta
Milk	Quarterly	Gamma scan

Gross alpha and beta analysis, using internal proportional counting techniques, are performed on selected samples as shown in tables 1 and 2. Because proper detection equipment is not available within the State, an agreement was made with the Environmental Protection Agency's Eastern Environmental Radiation Laboratory to perform tritium analysis of the surface water samples from the AN–1 environs.

Before environmental samples are counted, a minimum detectable activity (MDA) is determined. If the activity of the sample is not equal to or greater than the MDA, the analytical results are reported as being less than the MDA. For determining yearly averages, the monthly averages not exceeding the MDA are considered to be zero.

Statewide surveillance program

The sampling stations for pasteurized milk, shown in figure 1, were chosen because of their proximity to milk production and distribution centers. Samples are collected on a monthly basis and are analyzed for gamma-emitting radionuclides, strontium-89 and strontium-90. Several stations in the statewide milk system are included in the Standby Milk Surveillance Network of the Environmental Protection Agency's Western Environmental Research Laboratory.

Figures 2 and 3 show the average monthly concentrations for iodine-131 and cesium-137 in milk for 1966 through 1969. The program was terminated in 1970 but was started up again in 1971. Also, no samples were collected during the last 3 months in both 1967 and 1968. In order to use semilog graph paper and simplify presentation of data, all monthly averages that were equal to zero or were less than the MDA have been plotted as a value of one. The peak values in 1966 are apparently due to the atmospheric testing of a nuclear device in China during April of that year (*2*). Figure 4 shows the average yearly concentrations in milk for cesium-137, iodine-131, barium-140, and total potassium. Because of the more lengthy analytical process for strontium-89 and strontium-90 determinations and the large number of samples, very little data are available for these two radionuclides in this part of the surveillance program.

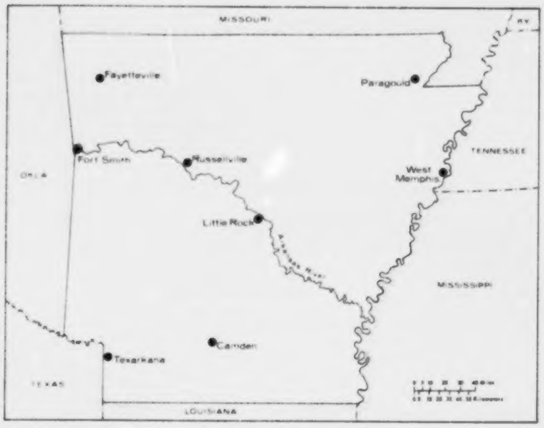
MISSOURI
KY
Fayetteville
Paragould
Fort Smith
Russellville
TENNESSEE
OKLA
West Memphis
Little Rock
MISSISSIPPI
Camden
Texarkana
TEXAS
LOUISIANA

Figure 1. State Pasteurized Milk Network

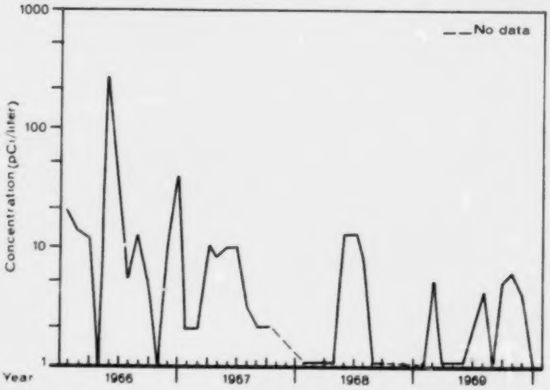

Figure 2. Average monthly iodine-131 concentration in pasteurized milk for all stations in State programs, 1966–1969

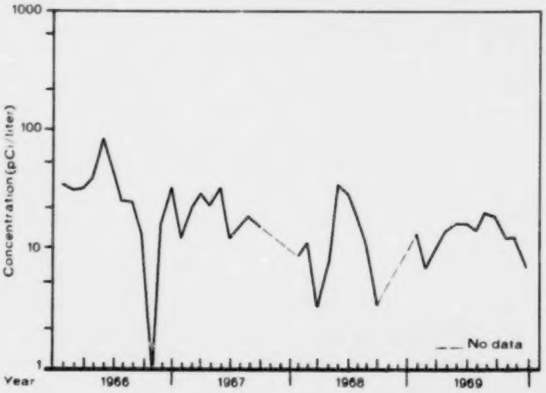

Figure 3. Average monthly cesium-137 concentration in pasteurized milk for all stations in State programs, 1966–1969

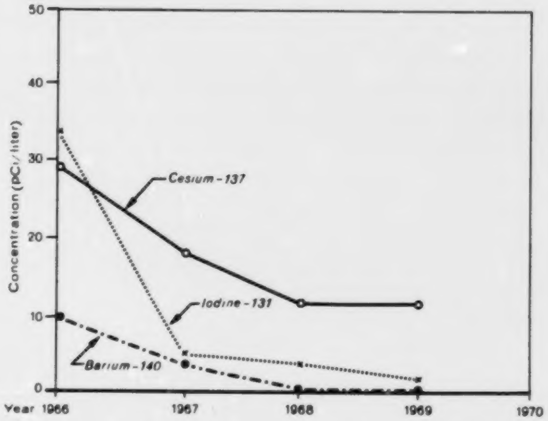

Figure 4. Average yearly concentration of selected radionuclides in pasteurized milk for all stations for all stations in State programs, 1966–1969

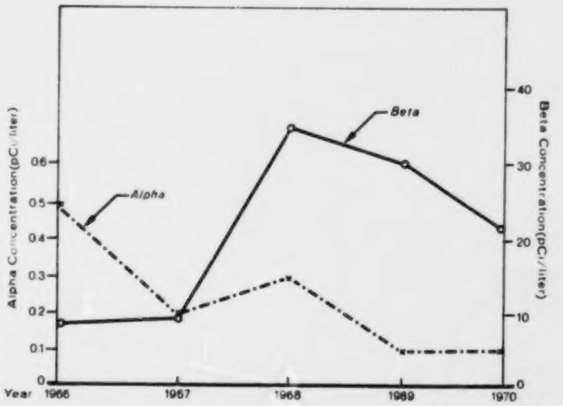

Figure 5. Average yearly gross alpha and beta concentration in precipitation at Little Rock, Ark., 1966–1970

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Precipitation samples, both rain and snow, are collected and analyzed for gross alpha and beta radioactivity. Figure 5 depicts the yearly averages for gross alpha and beta radioactivity in precipitation for 1966 through 1970.

The air analysis data from Little Rock are not presented in this report since they are routinely published by the Environmental Protection Agency in *Radiation Data and Reports.*

Nuclear facilities environmental surveillance programs

In the late 1950's and early 1960's, the primary emphasis in environmental radiation surveillance was on statewide and/or nationwide programs. However, the moratorium on atmospheric nuclear tests following the signing of the Test Ban Treaty of 1963 has decreased the need for large area surveillance programs. The expanding use of nuclear power for electrical generating plants has resulted in both State and Federal Public Health Agencies increasing their responsibilities in surveillance of nuclear power plants and other nuclear facilities. In the context of this new emphasis in surveillance, the Division of Radiological Health is presently conducting, as has been previously noted, two source oriented programs: (1) an operational program at the SEFOR plant near Fayetteville, Ark., and (2) a preoperational program near Russellville, Ark., for AN–1. The surveillance activities by the Division of Radiological Health are conducted only in locations external to the facility's fenced area.

The prime objectives of environmental surveillance programs for nuclear facilities are (1) to verify the adequacy of source control, (2) to provide a source of data for public information, and (3) in certain situations, to provide data for estimating population doses.

SEFOR reactor

The SEFOR reactor near Fayetteville became operational during the first week of May 1969. In order to obtain reliable baseline data, a preoperational surveillance program

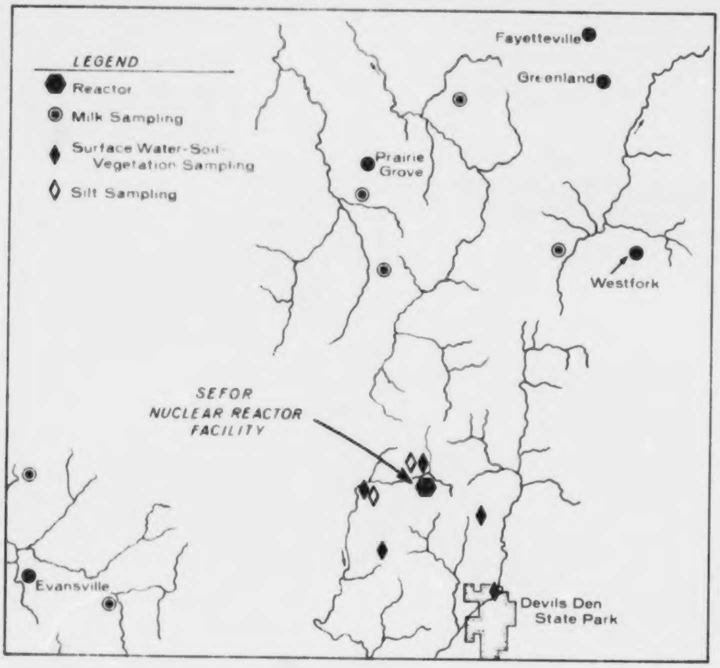

Figure 6. Environmental surveillance sampling locations at the SEFOR facility

was conducted for 2 years prior to reactor startup. Table 1 shows the operational phase system as it now exists while figure 6 shows the location of sampling stations. Since the production of milk in the reactor environs is limited, only a small number of sampling locations have been established.

Fall Creek, which is the main hydrological feature of the area, flows eventually into the Van Buren, Ark., public water supply. While the facility does not discharge liquid waste directly to Fall Creek, laundry wastes may reach the stream after migration through the facility's tile field. Therefore, sampling stations were established to monitor the possible low-level liquid effluents.

Figure 7 shows the average yearly iodine-131 and cesium-137 concentrations in the milk samples collected in the SEFOR environs for 1966 through 1970. As can readily be seen, the concentrations in milk for both of these radionuclides have decreased considerably since 1966. The principal reason for the high averages during 1966 was apparently a result of a multiple deposition of radioactive material on Northwest Arkansas from an atmospheric nuclear weapon detonated on the Chinese mainland during April of that year (*2*). Figure 8 shows the monthly averages for gross beta radioactivity contained in air samples collected at SEFOR from the middle of 1967 through 1970. The fluctuation in the measurements of these samples compared favorably to the fluctuation in the data for the Little Rock station of the Radiation Alert Network of the Environmental Protection Agency for the same period of time. Tables 3 and 4 summarize the analytical results of the environmental samples collected in the SEFOR environs during 1969 and 1970, respectively.

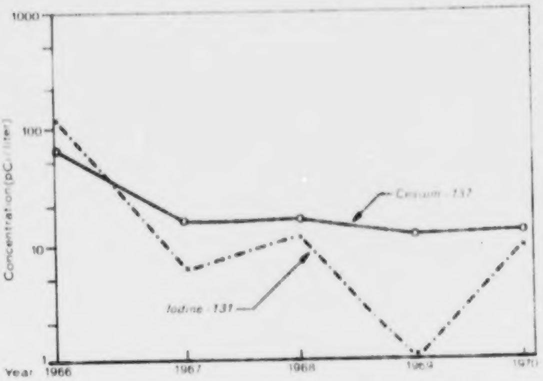

Figure 7. Average yearly cesium-137 and iodine-131 concentrations in raw milk from SEFOR sampling locations, 1966–1970

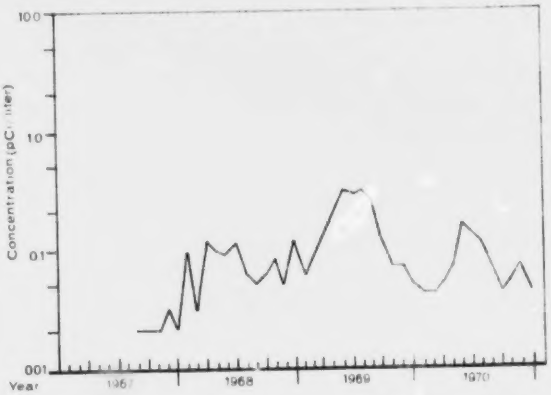

Figure 8. Average monthly gross beta concentration in air from SEFOR sampling location, 1967–1970

Table 3. Average radioactivity in environmental samples at SEFOR, 1969[a]

Type of sample	Number of samples	Average radioactivity concentration[b]													
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{232}Th	^{65}Zn	^{140}Ba	^{214}Bi	^{89}Sr	^{90}Sr	Gross alpha	Gross beta
Milk (pCi/liter)	9	NA	1	NA	8	NA	NA	NA	NA	0.4	NA	0	11	NA	NA
Surface water (pCi/liter)	4	0	0	0	0	0	0	0	0	0	0	NA	NA	NA	NA
Silt (pCi/g dry weight)	4	0	0	0	0	0	0	.3	0	0	0	NA	NA	6	7
Grass (pCi/g dry weight)	4	1	0	5	1	2	.1	NA	0	0	NA	NA	NA	11	284

[a] No soil or aquatic biota samples were taken during this period.

[b] Zero indicates that sample average is equal to or less than the MDA. NA, no analysis.

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Table 4. Average radioactivity in environmental samples at SEFOR, 1970[a]

Type of sample	Number of samples	Average radioactivity concentration[b]													
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{232}Th	^{65}Zn	^{140}Ba	^{214}Bi	^{89}Sr	^{90}Sr	Gross alpha	Gross beta
Milk (pCi/liter)	11	NA	10	NA	13	NA	NA	NA	NA	5	NA	NA	NA	NA	NA
Surface water (pCi/liter)	6	10	0	0	0	0	0	0	0	0	0	NA	NA	0	1
Soil (pCi/g dry weight)	5	2	1	1	0.4	0.3	0	0.6	0	0	1	NA	NA	8	27
Grass (pCi/g dry weight)	1	2	0	5	.4	7	0	NA	0	0	NA	NA	NA	NA	NA

[a] No silt or aquatic biota samples were taken during this period.
[b] Zero indicates that sample average is equal to or less than the MDA.
NA, no analysis.

In summary, the Division of Radiological Health has conducted an environmental surveillance program at the SEFOR facility for approximately 5 years. This period of time spans both the preoperational and operational phases of this research reactor. In comparing preoperational and operational surveillance data it can be concluded that SEFOR has not produced a measurable increase in the environmental radioactivity level of its environs.

Arkansas Nuclear One

The surveillance system surrounding the Arkansas Nuclear One (AN–1) site is a comprehensive network typical of other PWR surveillance systems. The area surrounding the plant site is used for agricultural, recreational, and residential purposes. The Dardanelle Reservoir (Arkansas River) is not used as a potable water supply; however, commercial and sport fishing on the reservoir, as well as other water recreation activities, appear to be potential exposure pathways to man. Sampling locations of surface waters, as well as other sample types are shown in figure 9 and are listed, along with the sampling frequencies in table 2.

As noted in the public health evaluation (*3*), milk is one of the prime exposure pathways to man and has been given emphasis in the AN–1 preoperational program consistent with the availability of sampling locations. Since the inception of the surveillance network, several dairymen in the area directly east of the site (vicinity of Atkins) have ceased operations. These dairies had been previously selected as sampling stations, which explains the void in the area coverage as shown in figure 9.

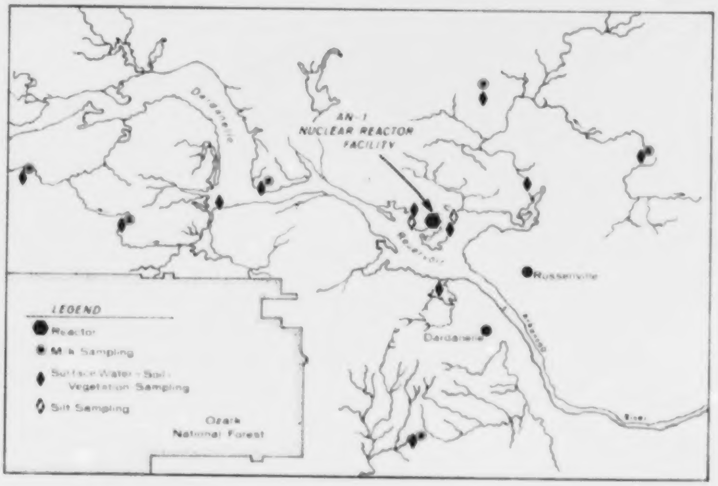

Figure 9. Environmental surveillance sampling locations at the AN–1 facility

A review of the preoperational program is conducted on an annual basis and is designed to update the system to insure that the most sensitive vectors are included. The early initiation has also insured the availability of reliable baseline data and that the objectives of the surveillance program will be met.

Tables 5 and 6 summarize the analytical results of the environmental samples collected at AN–1 during 1969 and 1970, respectively. The operational surveillance program at AN–1 will be essentially the same as the preoperational program except for a difference in sampling frequency. For example, samples that are now collected quarterly will be collected monthly and those now collected semiannually will be collected and analyzed quarterly.

Summary and conclusions

A discussion has been given on the environmental radiation surveillance programs in Arkansas and some of the data that was collected during 1966 through 1970 have been presented. While a statewide milk surveillance network will be maintained in the future, the primary emphasis will be on nuclear facility offsite surveillance activities. The possibility of the effluent releases from the SEFOR nuclear plant adversely affecting the general public is quite small. This is due not only to the design of the SEFOR facility but also to the reactor's geographic location. However, the experience gained in source-oriented surveillance activities at this nuclear facility has been beneficial in establishing and operating the surveillance program at Arkansas Nuclear One. The recent controversies on the potential hazards of nuclear reactors and the new proposed AEC regulations that will reduce the discharge limits of light water nuclear power plants (*4*) have increased the importance of the data that will be collected at Arkansas Nuclear One.

REFERENCES

(*1*) PORTER, C. R., B. KAHN, M. W. CARTER, G. L. REHNBERG, and E. W. PEPPER. Determination of radiostrontium in food and other environmental samples. Environ Sci Technol 1:745–750 (September 1967).

(*2*) STRONG, A. B., C. R. PORTER, M. W. CARTER, and E. F. WILSON. The localization of fallout in the United States from May 1966 Chinese nuclear test. Public Health Rep 82:487–495 (June 1967).

Table 5. Average radioactivity in environmental samples at Arkansas Nuclear One, 1969

Type of sample	Number of samples	Average radioactivity concentration													
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{232}Th	^{65}Zn	^{140}Ba	^{214}Bi	^{89}Sr	^{90}Sr	Gross alpha	Gross beta
Milk (pCi/liter)	15	NA	5	NA	20	NA	NA	NA	NA	4	NA	8	21	NA	NA
Surface water (pCi/liter)	19	0	0	0	1	1	0	0	0	0	8	NA	NA	0	2
Soil (pCi/g dry weight)	4	0	0	1	1	1	0	1	0	0	1	NA	NA	0	14
Silt (pCi/g dry weight)	4	0	0	.4	.3	.5	0	1	0	0	1	NA	NA	0	13
Grass (pCi/g dry weight)	4	0	0	3	.2	3	0	NA	0	0.1	NA	NA	NA	0	237

NA, no analysis.

Table 6. Average radioactivity in environmental samples at Arkansas Nuclear One, 1970

Type of sample	Number of samples	Average radioactivity concentration													
		^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{232}Th	^{65}Zn	^{140}Ba	^{214}Bi	^{89}Sr	^{90}Sr	Gross alpha	Gross beta
Milk (pCi/liter)	14	NA	4	NA	15	NA	NA	NA	NA	0	NA	NA	NA	NA	NA
Surface water (pCi/liter)	16	0	5	0	3	0	0	0	1	1	0	NA	NA	0	8
Soil (pCi/g dry weight)	6	2	11	.5	.5	0.4	0	1	0	0	1	NA	NA	8	29
Silt (pCi/g dry weight)	8	2	17	.4	.2	.2	0	.5	0	1	1	NA	NA	9	36
Grass (pCi/g dry weight)	2	2	NA	4	4	8	0	NA	0	.1	NA	NA	NA	NA	NA

NA, no analysis.

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(3) U.S. PUBLIC HEALTH SERVICE. Public health evaluation—Russellville nuclear power station, NF-68-15. Environmental Surveillance and Control Program, National Center for Radiological Health, Department of Health, Education and Welfare, Rockville, Md. 20852 (June 1968).

(4) U.S. ATOMIC ENERGY COMMISSION. Proposed rulemaking. Licensing of production and utilization facilities, light-water-cooled nuclear power reactors. Federal Register 10 CFR, Part 50, 36: 11113–11117. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (June 9, 1971).

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, September 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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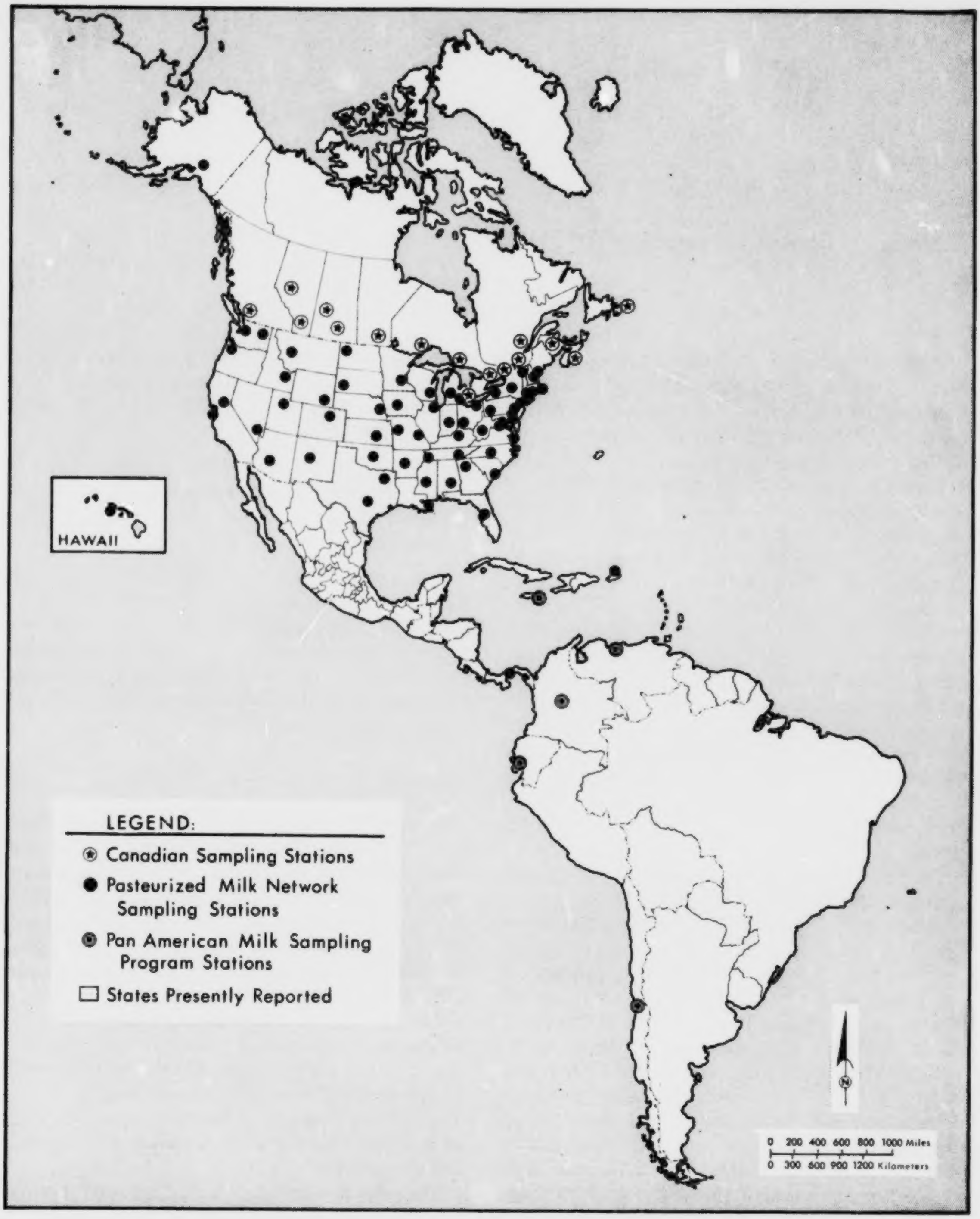
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports,* 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140)

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration in milk	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting-level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧100 pCi/liter.

Table 2. Concentrations of radionuclides in milk for September 1971 and 12-month period, October 1970 through September 1971

Sampling locations		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	23	11
Alaska:	Palmer[c]	P	4	5	13	14
Ariz:	Phoenix[c]	P	NA	1	0	0
Ark:	Little Rock[c]	P	14	12	21	12
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	4	0	0
	Del Norte	P	NA		NA	
	Fresno	P	0	2	0	2
	Humboldt	P	3	4	0	4
	Los Angeles	P	0	2	0	0
	Mendocino	P	2	6	0	5
	Sacramento	P	2	3	0	2
	San Diego	P	0	1	12	2
	Santa Clara	P	0	2	0	2
	Shasta	P	2	3	12	4
	Sonoma	P	0	3	13	4
Colo:	Denver[c]	P	NA	4	0	6
	East	R	(d)		NS	<0
	Northeast	R	(d)		NS	<1
	Northwest	R	(d)		<0	<0
	South Central	R	(d)		NS	NS
	Southeast	R	(d)		<0	<0
	Southwest	R	(d)		<0	<3
	West	R	(d)		NS	<0
Conn:	Hartford[c]	P	NA	7	0	9
	Central	P	7	7	13	15
Del:	Wilmington[c]	P	NA	9	0	6
D.C:	Washington[c]	P	NA	7	0	9
Fla:	Tampa[c]	P	5	5	52	44
	Central	R	6	6	64	40
	North	R	14	9	21	28
	Northeast	R	5	7	47	32
	Southeast	R	7	6	45	66
	Tampa Bay area	P	9	6	47	45
	West	R	13	10	27	17
Ga:	Atlanta[c]	P	NA	11	15	14
Hawaii:	Honolulu[c]	P	2	2	0	2
Idaho:	Idaho Falls[c]	P	5	5	0	6
Ill:	Chicago[c]	P	7	7	11	11
Ind:	Indianapolis[c]	P	NA	7	12	6
	Central	P	8	8	15	12
	Northeast	P	8	9	15	15
	Northwest	P	9	10	20	13
	Southeast	P	9	10	10	14
	Southwest	P	10	10	15	13
Iowa:	Des Moines[c]	P	NA	6	0	3
	Iowa City	P	6	8	13	15
	Des Moines	P	6	7	13	12
	Spencer	P	6	5	12	12
	Little Cedar	P	6	6	16	16
Kans:	Wichita[c]	P	6	7	0	2
	Coffeyville	P	9	9	14	15
	Dodge City	P	6	7	9	6
	Falls City, Nebr	R	NS		NS	
	Hays	P	6	9	8	7
	Kansas City	P	5	9	10	15
	Topeka	P	6	9	12	11
	Wichita	P	6	11	14	11
Ky:	Louisville[c]	P	NA	9	12	5
La:	New Orleans[c]	P	15	14	23	20
Maine:	Portland[c]	P	NA	9	26	22
Md:	Baltimore[c]	P	NA	8	0	6
Mass:	Boston[c]	P	9	9	19	16
Mich:	Detroit[c]	P	NA	7	11	11
	Grand Rapids[c]	P	NA	9	0	12
	Bay City	P	NS	6	NS	15
	Charlevoix	P	9	10	15 (2)	15
	Detroit	P	6	9	11	7
	Grand Rapids	P	5	7	15	9
	Lansing	P	6	7	17	15
	Marquette	P	9	10	21 (2)	24
	Monroe	P	3	5	0 (2)	4
	South Haven	P	7	7	12	9
Minn:	Minneapolis[c]	P	NA	9	0	15
	Bemidji	P	8	9	22	20
	Duluth	P	16	15	30	23
	Fergus Falls	P	8	7	18	12
	Little Falls	P	16	17	45	28
	Mankato	P	5	6	0	11
	Minneapolis	P	13	19	17	15
	Rochester	P	7	8	15	12
	Worthington	P	NS	5	NS	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1971 and 12-month period, October 1970 through September 1971—continued

Sampling locations		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued						
Miss:	Jackson[c]	P	NA	12	16	10
Mo:	Kansas City[c]	P	NA	7	15	6
	St. Louis[c]	P	NA	6	0	6
Mont:	Helena[c]	P	NA	6	0	10
Nebr:	Omaha[c]	P	NA	6	0	4
Nev:	Las Vegas[c]	P	NA	2	0	1
N.H:	Manchester[c]	P	NA	9	21	21
N.J:	Trenton[c]	P	NA	9	0	10
N. Mex:	Albuquerque[c]	P	NA	3	0	0
N.Y:	Buffalo[c]	P	7	7	13	12
	New York City[c]	P	NA	9	0	14
	Syracuse[c]	P	NA	7	0	10
	Albany	P	0	7	<0 (4)	<0
	Buffalo	P	0	0	<0	<0
	Massena	P	6	7	22 (2)	22
	New York City	P	NS		NS	
	Syracuse	P	6	5	<0	<0
N.C:	Charlotte[c]	P	NA	11	16	12
N. Dak:	Minot[c]	P	NA	10	18	10
Ohio:	Cincinnati[c]	P	NA	7	0	2
	Cleveland[c]	P	NA	8	0	9
Okla:	Oklahoma City[c]	P	NA	6	0	8
Oreg:	Portland[c]	P	4	5	17	6
	Baker	P	5	3	<0	5
	Coos Bay	P	0	5	24	9
	Eugene	P	0	2	<0	2
	Medford	P	4	2	<0	3
	Portland composite	P	NS	6	NS	4
	Portland local	P	6	4	15	11
	Redmond	P	6	3	<0	2
	Tillamook	P	0	5	<0	13
Pa:	Philadelphia[c]	P	NA	8	0	9
	Pittsburgh[c]	P	NA	11	0	12
	Dauphin	P	NS	3	NS	13
	Erie	P	7	7	0	15
	Philadelphia	P	4	8	14	15
	Pittsburgh	P	6	11	13	17
R.I:	Providence[c]	P	NA	8	14	18
S.C:	Charleston[c]	P	9	9	13	15
S. Dak:	Rapid City[c]	P	NA	6	11	6
Tenn:	Chattanooga[c]	P	NA	9	13	10
	Memphis[c]	P	NA	7	0	8
	Chattanooga	P	7	8	17	16
	Clinton	R	8	9	0 (2)	16
	Fayetteville	R	3	9	0 (2)	13
	Kingston	P	4	7	16	18
	Knoxville	P	8	6	0 (2)	13
	Lawrenceburg	R	5	5	0 (3)	5
	Nashville	P	7	6	0	13
	Pulaski	R	8	8	0	4
Tex:	Austin[c]	P	NS	1	NS	0
	Dallas[c]	P	NA	6	0	5
	Amarillo	R	3	3	0	2
	Corpus Christi	R	NS	4	NS	0
	El Paso	R	NS	3	NS	0
	Fort Worth	R	NS	4	NS	0
	Harlingen	R	NS	2	NS	0
	Houston	R	NS	7	NS	16
	Lubbock	R	NS	3	NS	0
	Midland	R	NS	2	NS	0
	San Antonio	R	3	4	0	0
	Texarkana	R	NS		NS	
	Tyler	R	11	15	0	15
	Uvalde	R	NS		NS	
	Wichita Falls	R	NS	6	NS	4
Utah:	Salt Lake City[c]	P	3	5	0	15
Vt:	Burlington[c]	P	NA	6	14	14
Va:	Norfolk[c]	P	NA	9	0	6
Wash:	Seattle[c]	P	NA	5	14	5
	Spokane[c]	P	NA	6	0	4
	Benton County	R	0	1	0	2
	Franklin County	R	NS	4	NS	5
	Sandpoint, Idaho	R	12	13	18	22
	Skagit County	R	9	8	12	12
W. Va:	Charleston[c]	P	NA	8	0	8
Wisc:	Milwaukee[c]	P	NS	6	NS	11
Wyo:	Laramie[c]	P	NA	5	0	1
CANADA:						
Alberta:	Calgary	P	6	7	19	20
	Edmonton	P	9	7	25	24

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for September 1971 and 12-month period, October 1970 through September 1971—continued

Sampling locations		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued						
British Columbia:	Vancouver	P	10	9	30	24
Manitoba:	Winnipeg	P	8	7	15	23
New Brunswick:	Fredericton	P	14	12	21	24
Newfoundland:	St. John's	P	31	17	35	31
Nova Scotia:	Halifax	P	9	11	22	24
Ontario:	Ottawa	P	14	14	35	33
	Sault Ste. Marie	P	11	12	33	26
	Thunder Bay	P	8	6	15	15
	Toronto	P	4	5	11	13
	Windsor	P	4	5	13	11
Quebec:	Montreal	P	7	7	14	18
	Quebec	P	12	10	24	30
Saskatchewan:	Regina	P	8	7	19	15
	Saskatoon	P	9	9	18	18
CENTRAL AND SOUTH AMERICA:						
Canal Zone:	Cristobal[c]	P	NA	1	0	8
Colombia:	Bogota	P	3	2	0	0
Chile:	Santiago	P	3	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Montego Bay	P	9	5	213	83
Puerto Rico:	San Juan[c]	P	NA	3	0	11
Venezuela:	Caracas	P	0	1	0	0
PMN network average[f]			7	7	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote[c].

NA, no analysis.
NS, no sample collected.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the

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above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, and cesium-137 for September 1971 and the 12-month period, October 1970 to September 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for September 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 was detected.

Strontium-90 monthly averages ranged from 0 to 16 pCi/liter in the United States for September 1971, and the highest 12-month average was 19 pCi/liter (Minneapolis, Minn., State) representing 9.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to

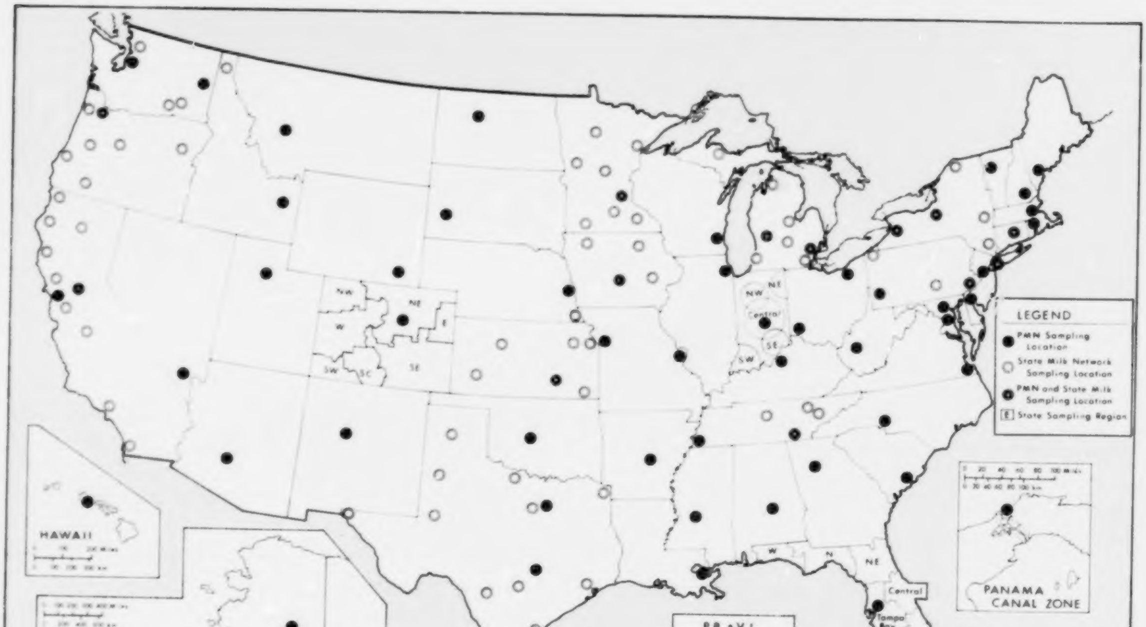
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
PMN and State Milk Sampling Location
E State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling locations in the United States

64 pCi/liter in the United States for September 1971, and the highest 12-month average was 66 pCi/liter (Southeast Florida), representing 1.8 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Table 3. Strontium-89 in milk, September 1971

Sampling location		Radionuclide concentration (pCi/liter)
Tenn:	Clinton (State)	5
	Fayetteville (State)	7
	Lawrenceburg (State)	6
Chile:	Santiago (PAHO)	17
Colombia:	Bogota (PAHO)	11
Ecuador:	Guayaquil (PAHO)	19
Venezuela:	Caracas (PAHO)	16

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

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(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, May–June 1970, Technical experiment 70–MKAQ–1. Analytical Quality Control Service, Bureau of Radiological Health (September 1970).

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radio Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	January-June 1971	December 1971
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Diet Samples	April-June 1971	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	March 1971	November 1971
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
New York	July 1969-June 1970	September 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April-June 1971	November 1971
Washington	July 1968-June 1969	February 1971

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, April and May 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 14 rivers during April 1971. Table 2 presents the sample results collected from 13 rivers during May 1971. The analytical procedure used for determining gross alpha and gross beta radioactivity

Table 1. Gross alpha and beta radioactivity in U.S. surface waters, April 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)				Gross beta radioactivity (pCi/liter)			
		Suspended solids		Dissolved solids		Suspended solids		Dissolved solids	
Cheyenne River:									
Edgemont, S. Dak	1	13		11		47		27	
Clinch River:									
Kingston, Tenn	4	<.8	(<.2-1)	<.2	(<.2-<.2)	4.7	(<1-9)	4.7	(3-8)
Great Miami River:									
Eldian Mills, Ohio	1	<.2		2		11		10	
Sellar Road, Ohio	1	<.2		1		5		8	
Fairfield, Ohio	1	<.2		1		1		12	
American Materials Bridge, Ohio	1	<.2		1		2		11	
Lost Bridge, Ohio	1	<.2		2		3		16	
Kentucky River:									
Lock & Dam No. 1, Ky	1	<.2		<.2		7		4	
Licking River:									
Covington, Ky	1	<.2		<.2		1		9	
Little Miami River:									
Cincinnati, Ohio	1	<.2		1		2		5	
Mississippi River:									
Burlington, Iowa	1	6		1		21		8	
Missouri River:									
Bismark, N. Dak	1	<.2		3		2		7	
Ohio River:									
Ironton, Ohio	1	<.2		<.2		7		4	
Greenup Dam, Ky	1	<.2		<.2		<1		7	
Portsmouth, Ohio	1	1		<.2		3		3	
Maysville, Ky	1	1		<.2		2		7	
Cincinnati, Ohio	4	<.4	(<.2-1)	<.6	(<.2-1)	2	(1-4)	4.7	(2-6)
Anderson Ferry, Ohio	1	<.2		<.2		3		8	
Miami Fort, Ohio	1	<.2		1		3		3	
Markland Dam, Ky	1	1		<.2		6		4	
Madison, Ind	1	<.2		<.2		7		6	
Meldahl Dam, Ohio	1	<.2		<.2		2		9	
Roanoke River:									
John Kerr Dam, Va	4	<.4	(<.2-1)	<.2	(<.2-<.2)	3.5	(2-7)	4.7	(4-6)
Susquehanna River:									
Holtwood, Pa	1	1		<.2		4		2	
Tennessee River:									
Bridgeport, Ala	1	<.2		<.2		1		7	
White Water River:									
State Line (Ohio-Ind)	1	<.2		1		6		10	
Yellowstone River:									
Sidney, Mont	1	<.2		1		6		10	

[a] Where more than one sample is analyzed during the month, the minimum and maximum values are in parentheses.

Table 2. Gross radioactivity in U.S. surface waters, May 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Cheyenne River:					
Edgemont, S. Dak	1	36	11	95	62
Clinch River:					
Kingston, Tenn	[a]5	<.2 (<.2- <.2)	<.2 (<.2- <.2)	<1 (<1-1)	5.8 (3-10)
Great Miami River:					
Eldean Mills, Ohio	1	<.2	3	<.2	9
Sellar Road, Ohio	1	<.2	2	1	2
Fairfield, Ohio	1	<.2	1	3	5
American Materials Bridge, Ohio	1	<.2	<.2	6	13
Lost Bridge, Ohio	1	1	<.2	3	22
Kentucky River:					
Lock and Dam No. 1, Ky	1	<.2	<.2	8	3
Licking River:					
Covington, Ky	1	7	<.2	3	2
Little Miami River:					
Cincinnati, Ohio	1	1	1	12	11
Mississippi River:					
Dubuque, Iowa	1	1	1	<1	7
Burlington, Iowa	1	1	1	<1	3
Ohio River:					
Ironton, Ohio	1	<.2	<.2	2	4
Greenup Dam, Ky	1	<.2	<.2	2	6
Portsmouth Ohio	1	1	<.2	3	2
Maysville, Ky	1	1	<.2	6	5
Cincinnati, Ohio	[a]5	<1.2 (<.2-2)	<.4 (<.2-1)	<4.7 (<1-11)	5.7 (2-7)
Miami Fort, Ohio	1	5	<.2	13	1
Anderson Ferry, Ohio	1	1	<.2	9	1
Markland Dam, Ky	1	1	<.2	4	6
Madison, Ind	1	1	<.2	7	5
Meldahl Dam, Ohio	1	1	<.2	7	5
Rainy River:	1				
International Falls, Minn	1	<.2	1	2	6
Roanoke River:					
John Kerr Dam	[a]3	<.2 (<.2-<.2)	<.2 (<.2-<.2)	<.1 (<1-<1)	2 (<1-4)
St. Lawrence River:					
Massena, N.Y	[a]3	<.2 (<.2-<.2)	<.2 (<.2-<.2)	1.3 (1-2)	4.7 (3-6)
Susquehanna River:					
Conowingo Dam, Md	1	<.2	<.2	2	2
Whitewater River:					
State line (Ohio-Ind.)	1	1	<.2	4	5

[a] Where more than one sample is analyzed, the minimum and maximum values at in parentheses.

are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be < 0.2 pCi/liter for gross alpha radioactivity and < 1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, (1971) New York, N.Y.

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

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Radioactivity in Florida Waters, 1969

Radiological and Occupational Health Section
Florida State Division of Health

The Florida State Division of Health samples raw surface, ground, and treated water in 13 hydrological subbasins as shown in figure 1. Samples collected on a variable frequency and analyzed for gross alpha and beta radioactivity during 1969 are presented in table 1.

In addition to sampling being done by the Florida State Division of Health, the Bioenvironmental Engineering Research Laboratory, University of Florida, samples surface, ground, and municipal water in Alachua County for gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1969 are summarized in table 2. Gross beta radioactivity above the minimum reported concentration was detected in 17 water samples taken in Alachua County. The 17 samples averaged 13 pCi/liter of gross beta radioactivity.

During 1969, only 17 samples out of a total of 83 collected from 63 sampling sites showed gross beta radioactivity greater than the minimum reported concentration. The 17 surface,

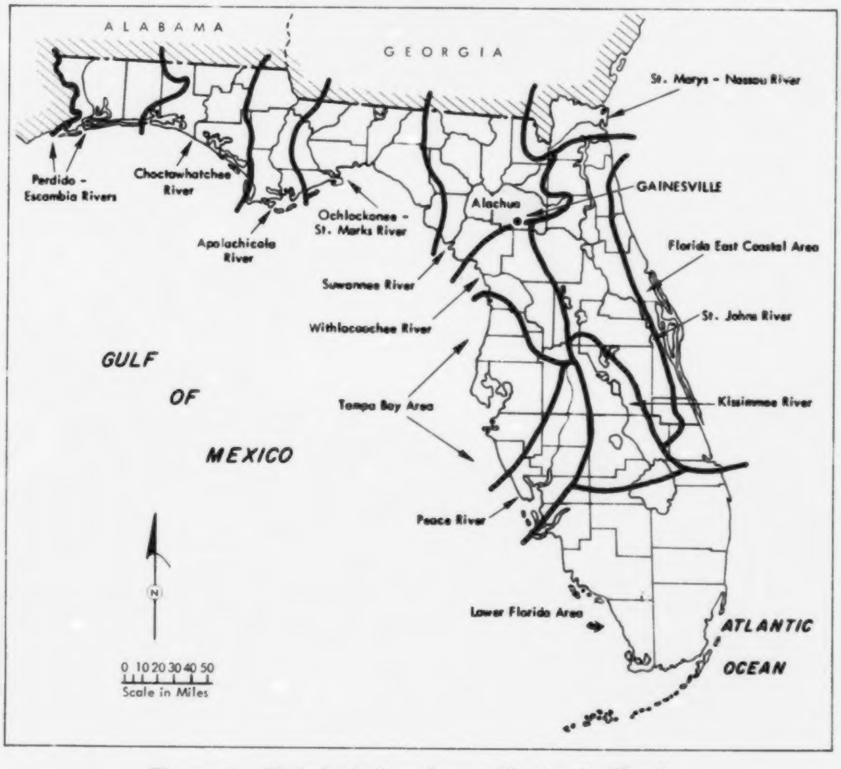
ALABAMA
GEORGIA
St. Marys - Nassau River
Perdido - Escambia Rivers
Choctawhatchee River
Apalachicola River
Ochlockonee - St. Marks River
Alachua
GAINESVILLE
Florida East Coastal Area
Suwannee River
Withlacoochee River
St. Johns River
GULF OF MEXICO
Tampa Bay Area
Kissimmee River
Peace River
N
Lower Florida Area
ATLANTIC OCEAN
0 10 20 30 40 50
Scale in Miles

Figure 1. Hydrological surface subbasins in Florida

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[1] Data taken from "Report of Florida Radiological Surveillance Programs, 1969" Bureau of Preventable Diseases, Radiological and Occupational Health Section, Jacksonville, Fla.

ground, and municipal water samples averaged 19 pCi/liter. The average gross beta radioactivity in water samples is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (*1*).

Table 1. Gross alpha and beta radioactivity in Florida water, 1969

Location	Number of samples	Alpha (pCi/liter)	Beta (pCi/liter)
St. John's River:			
Raw	14	<7	<10
	1	<7	11
	1	<7	12
	1	<7	53
Treated	6	<7	<10
Sewage treatment plants	[a]2	<7	<10
St. Mary's, Nassau, and Amelia Rivers:			
Raw	1	<7	62
	1	<7	<10
Lower Florida area:			
Raw	10	<7	<10
Treated	14	<7	<10
	[a]1	<7	19
	[a]1	<7	12
Sewage treatment plant	1	<7	12
	1	<7	21
	[a]1	<7	13
	[a]1	<7	16
	[a]1	<7	11
	[a]1	<7	<10
Florida East Coastal area:			
Raw	2	<7	<10
Treated	3	<7	<10
Kissimmee River Basin:			
Treated	1	<7	12
Sewage treatment plant	[a]1	<7	<10
	[a]1	<7	14
Peace River:			
Treated	3	<7	<10
Tampa Bay area:			
Raw	1	<7	<10
Treated	6	<7	<10
Sewage treatment plants	[a]3	<7	12
	[a]1	<7	15
Withlacoochee and Waccasassa Rivers:			
Treated	2	<7	<10

[a] Composite sample.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 2. Gross beta radioactivity in Florida water, 1969

Location	Radioactivity concentration (pCi/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Summary
Alachua County: (18 sampling locations)													
Maximum	12.6	7.5	15.6	7.2	9.6	6.8	21.4	9.7	14.3	8.9	10.4	13.1	21.4
Average	2.9	3.2	7.9	3.7	4.5	3.2	8.6	5.2	5.2	4.9	4.8	5.0	4.9
City of Gainesville:													
Maximum	10.9	10.1	10.1	6.4	7.2	8.6	7.5	10.0	10.4	6.7	15.6	7.2	15.6
Average	4.5	4.0	3.6	2.9	3.2	3.8	3.1	3.7	3.5	2.9	4.0	2.8	3.5

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
Plutonium in Airborne Particulates	January-March 1971	November 1971
Mexican Air Monitoring Program	August-December 1970 and January 1971	October 1971

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1. Radiation Alert Network September 1971

Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, North Carolina 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1971.

All field estimates reported were within normal limits for the reporting station.

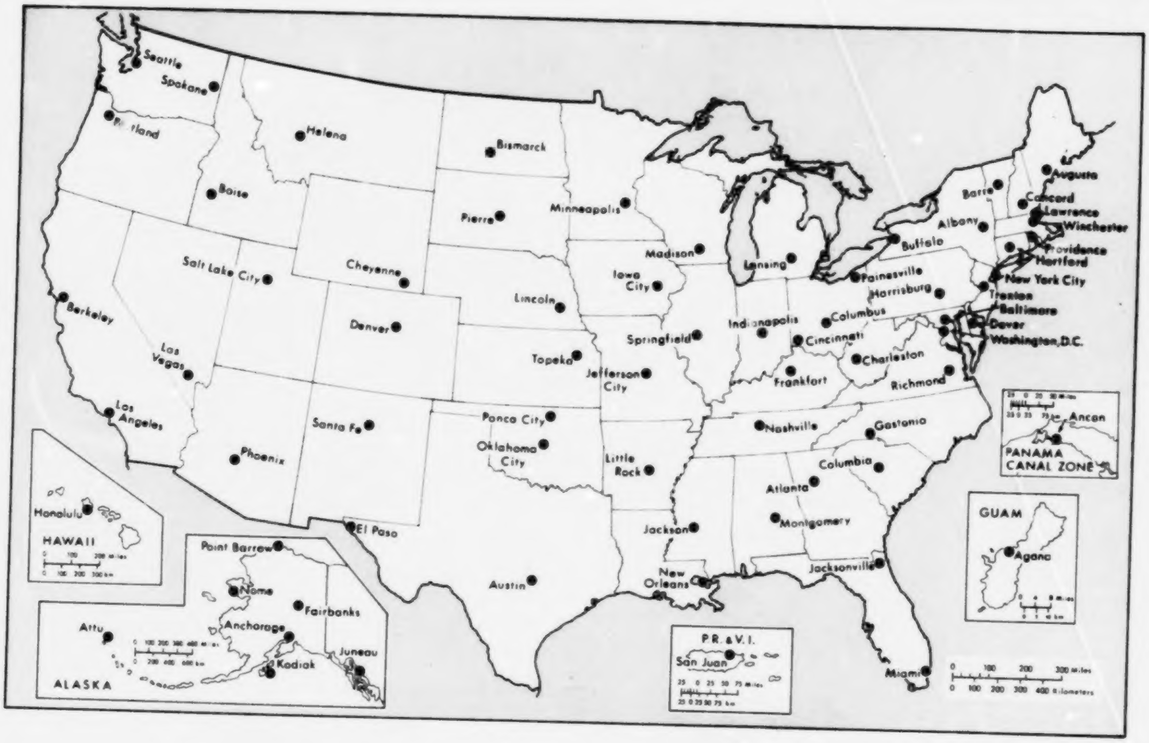
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Berkeley
Lincoln
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Charleston
Las Vegas
Topeka
Jefferson City
Frankfort
Richmond
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
PANAMA CANAL ZONE
Ancon
Honolulu
HAWAII
El Paso
Jackson
Montgomery
GUAM
Agana
Point Barrow
New Orleans
Jacksonville
Nome
Austin
Fairbanks
Attu
Anchorage
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Miami
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m^3)			Precipitation				
			Maximum	Minimum	Average[a]	Number of samples	Total depth (mm)	Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	20	4	0	1	2	112	2	112	108
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	20	1	0	0	10	54	10	54	33
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	11	4	1	2	0				
Ark:	Little Rock	11	2	0	1	0				
Calif:	Berkeley	18	1	0	0	1	7	1	7	0
	Los Angeles	16	3	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	21	6	0	2	7	68			
Conn:	Hartford	21	1	0	1	3	38	3	38	0
Del:	Dover	21	1	0	0	0				
D.C:	Washington	25	1	0	0	0				
Fla:	Jacksonville	20	1	0	0	5	49			
	Miami	17	0	0	0	11	175	10	149	0
Ga:	Atlanta	21	2	1	2	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	20	1	0	0	6	76			
Idaho:	Boise	21	3	0	2	3	14	3	14	0
Ill:	Springfield	1	2	2	2	0				
Ind:	Indianapolis	21	2	0	1	0				
Iowa:	Iowa City	20	5	0	1	4	97	4	97	28
Kans:	Topeka	21	6	0	2	3	25	3	25	0
Ky:	Frankfort	0				0				
La:	New Orleans	19	1	0	0	11	333			
Maine:	Augusta	18	2	0	1	5	86	4	72	0
Md:	Baltimore	17	2	0	1	4	40	4	40	0
Mass:	Lawrence	18	2	0	1	4	32	4	32	0
	Winchester	19	3	0	1	4	43	4	43	0
Mich:	Lansing	19	1	0	1	7	116	7	116	12
Minn:	Minneapolis	17	3	0	1	5	73	5	73	12
Miss:	Jackson	17	2	0	0	3	105			
Mo:	Jefferson City	20	5	0	2	5	58	5	58	0
Mont:	Helena	19	3	0	1	5	33	5	33	0
Nebr:	Lincoln	19	11	1	4	1	4	1	4	1
Nev:	Las Vegas	20	3	1	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	6	50	6	50	2
N. Mex:	Santa Fe	11	2	1	1	1	23	1	23	0
N.Y:	Albany	13	1	0	0	0				
	Buffalo	20	1	0	1	0				
	New York City	0				0				
N.C:	Gastonia	6	12	3	7	0				
N. Dak:	Bismarck	19	4	0	2	5	56	5	56	10
Ohio:	Cincinnati	0				0				
	Columbus	2	1	1	1	0				
	Painesville	20	3	0	1	7	123	7	123	50
Okla:	Oklahoma City	0				0				
	Ponca City	21	4	0	1	5	158	4	147	0
Oreg:	Portland	21	1	0	0	8	67	8	67	0
Pa:	Harrisburg	12	1	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	2	0	1	4	31	4	31	0
S.C:	Columbia	15	4	0	1	4	83	4	83	0
S. Dak:	Pierre	19	5	1	2	0				
Tenn:	Nashville	4	2	0	1	1	31	1	31	0
Tex:	Austin	0				0				
	El Paso	21	5	0	2	0				
Utah:	Salt Lake City	25	4	1	1	1	4	1	4	2
Vt:	Barre	21	3	0	1	6	35	6	35	4
Va:	Richmond	18	1	0	0	2	60	2	60	0
Wash:	Seattle	8	0	0	0	4	58			
	Spokane	8	1	0	0	0				
W. Va:	Charleston	21	2	0	1	9	192	9	192	17
Wisc:	Madison	20	3	0	1	4	37	4	37	4
Wyo:	Cheyenne	19	4	0	2	3	35	3	35	13
Network summary		1,001	12	0	1	179	84	4	61	9

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] September 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for September 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.1	0.1	0.1	37	1.5
Coral Harbour	4	.1	.0	.1	66	1.2
Edmonton	4	.1	.1	.1	16	.8
Ft. Churchill	4	.1	.0	.1	49	4.3
Fredericton	4	.1	.1	.1	27	2.0
Goose Bay	4	.0	.0	.0	40	3.0
Halifax	4	.1	.1	.1	29	1.5
Inuvik	4	.0	.0	.0	46	1.1
Montreal	4	.1	.1	.1	30	2.3
Moosonee	4	.1	.1	.1	14	2.3
Ottawa	4	.1	.1	.1	15	.8
Quebec	1	.1	.1	.1	30	4.0
Regina	4	.1	.1	.1	110	1.1
Resolute	4	.1	.0	.0	21	.3
St. John's, Nfld	4	.1	.0	.1	26	2.3
Saskatoon	4	.1	.1	.1	178	1.0
Sault Ste. Marie	4	.1	.1	.1	43	4.5
Thunder Bay	3	.1	.1	.1	44	4.7
Toronto	4	.1	.1	.1	53	2.0
Vancouver	4	.1	.0	.0	29	2.6
Whitehorse	4	.1	.0	.1	29	.6
Windsor	4	.1	.1	.1	8	.6
Winnipeg	4	.1	.1	.1	98	4.9
Yellowknife	4	.1	.0	.1	58	1.5
Network summary	118	0.1	0.0	0.1	46	2.1

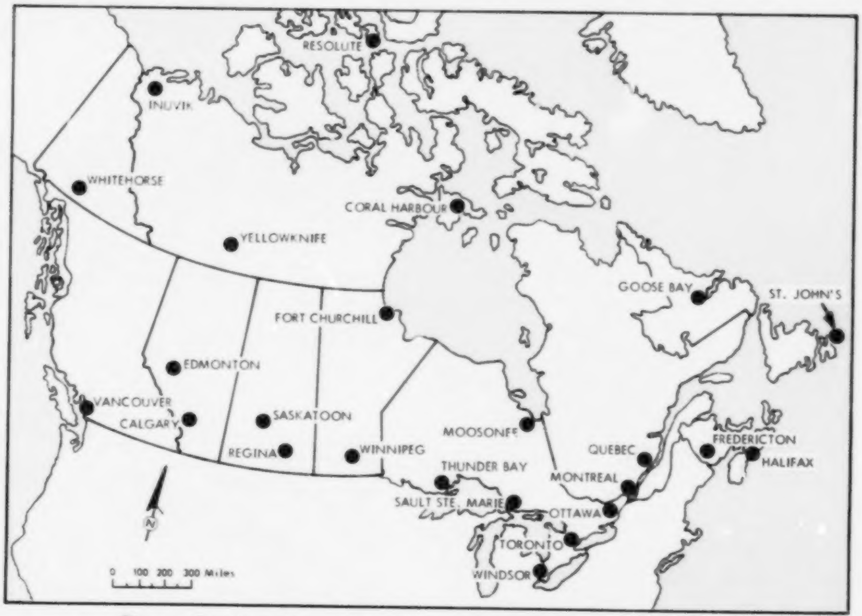
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
REGINA
WINNIPEG
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program September 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The September 1971 air monitoring results from the participating countries are given in table 3.

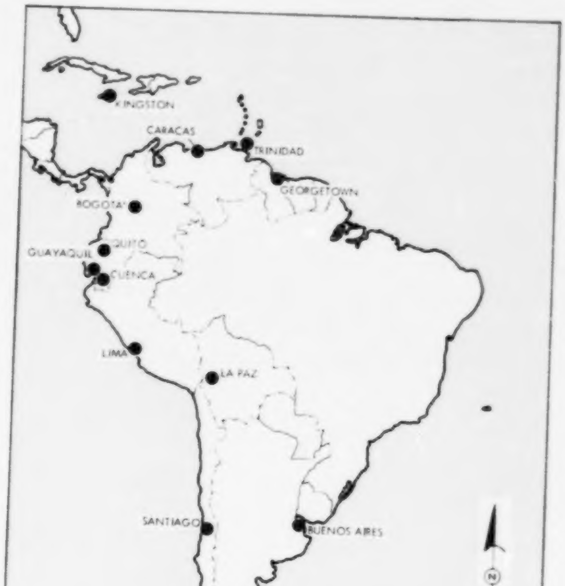

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, September, 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	11	3.47	0.87	1.90
Chile:	Santiago	30	1.05	.04	.43
Colombia:	Bogota	22	.49	.06	.18
Ecuador:	Cuenca	19	1.01	.02	.48
	Guayaquil	21	2.11	.15	.83
	Quito	14	.30	.02	.15
Guyana:	Georgetown	17	.51	.03	.20
Jamaica:	Kingston	0			
Peru:	Lima	25	1.16	.24	.71
Venezuela:	Caracas	20	.34	.02	.13
West Indies:	Trinidad	21	.63	.02	.16
Pan American summary		200	3.47	0.02	0.47

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).
(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).
(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).
(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).
(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summary of the environmental radioactivity data follow for the Argonne National Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory July–December 1970[2]

University of Chicago
Lemont, Ill.

Argonne National Laboratory conducts a continuous program to measure the radioactivity on the laboratory grounds and in the area near the laboratory. The primary purpose of this phase of the laboratory's radiation protection program is to determine the magnitude, origin, and identity of any radioactivity not naturally present in the environment. Of special interest is the detection of any radioactive materials released to the environment by Argonne. If activity released by Argonne begins to approach significant levels, immediate steps will be taken to eliminate or reduce the release.

The radioactivity of the environment is determined by measuring the concentrations of radionuclides in naturally-occurring materials collected on the Argonne site and from locations up to 100 miles from the site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these media. Plants, milk, soil, precipitation, animals, and material from the beds of lakes and streams are also collected and analyzed. The results included in this report are those that are pertinent to the evaluation of Argonne's contribution to the environmental radioactivity and to the differentiation of Argonne activity from fallout and other sources. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

The radioactivity of particulate matter in air was determined by drawing air through filter paper at a known rate and measuring the radioactivity of the particles collected by the paper. The samples were collected continuously at seven locations on the Argonne site and at six locations off the site. At one location on the

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[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July-December 1970," University of Chicago, Lemont, Ill.

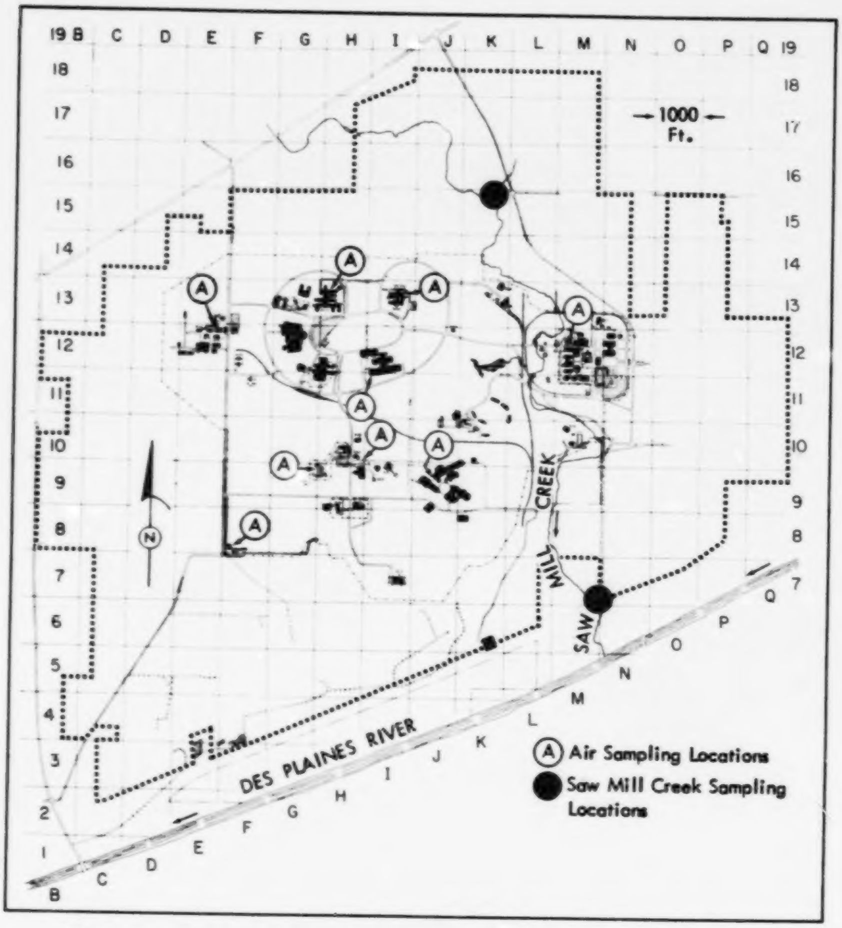

Figure 1. Onsite sampling locations at Argonne National Laboratory

Table 1. Alpha and beta radioactivity in air-filter samples[a]
Argonne National Laboratory, July-December 1970

Period	Location	Number of samples	Alpha radioactivity (fCi/m^3)			Beta radioactivity (pCi/m^3)		
			Average	Minimum	Maximum	Average	Miminum	Maximum
July	Onsite	26	3.1	1.4	6.0	0.48	0.19	0.72
	Offsite	23	3.9	1.6	7.8	.55	.33	.93
August	Onsite	27	3.1	2.0	6.2	.38	.18	.78
	Offsite	22	4.4	2.2	10.6	.41	.22	.78
September	Onsite	22	2.1	.91	5.4	.13	.034	.27
	Offsite	20	2.7	.72	6.6	.15	.062	.26
October	Onsite	25	2.5	1.2	4.3	.14	.034	.22
	Offsite	25	2.9	.81	4.6	.14	.092	.23
November	Onsite	27	2.3	1.2	4.3	.13	.066	.25
	Offsite	24	2.4	.63	4.9	.14	.082	.31
December	Onsite	25	2.9	1.6	4.2	.12	.070	.21
	Offsite	25	3.5	1.9	6.7	.11	.050	.23
Annual summary	Onsite	289	3.0	0.91	11.7	0.26	0.03	1.09
	Offsite	258	3.9	0.63	12.7	0.28	0.03	1.16

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

Table 2. Gamma-ray radioactivity in air-filter samples
Argonne National Laboratory, July-December 1970

Radionuclide	Location	Concentration[a] (pCi/m^3)						
		July	Aug	Sept	Oct	Nov	Dec	Summary
Barium-lanthanum-140	Onsite	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	(a)
	Offsite	< .001	< .001	< .001	< .001	.003	< .001	(a)
Beryllium-7	Onsite	.092	.089	.057	.085	.072	.060	0.08
	Offsite	.099	.110	.066	.084	.071	.056	.09
Cerium-141	Onsite	.003	.002	< .001	.001	.003	.001	(a)
	Offsite	.004	.002	< .001	.001	.003	.001	(a)
Cerium-144	Onsite	.110	.087	.030	.028	.018	.013	.05
	Offsite	.110	.097	.031	.029	.018	.012	.05
Cesium-137	Onsite	.007	.007	.003	.003	.002	.002	(a)
	Offsite	.009	.008	.003	.002	.002	.001	(a)
Iodine-131	Onsite	< .01	< .01	< .01	.01	.01	.07	.01
	Offsite	< .01	< .01	< .01	.01	.01	.12	.02
Ruthenium-103	Onsite	.010	.005	.002	.002	.005	.004	.01
	Offsite	.011	.006	.002	.002	.005	.005	.01
Ruthenium-rhodium-106	Onsite	.074	.070	.025	.023	.018	.017	.04
	Offsite	.078	.071	.031	.028	.020	.017	.04
Zirconium-niobium-95	Onsite	.130	.086	.024	.021	.016	.011	.06
	Offsite	.140	.094	.025	.020	.016	.010	.07

[a] Because of a change in counting equipment in the second half of the year which improved sensivitity by a factor of ten, no meaningful average could be calculated.

site the filter paper was changed daily; at all other locations the filter papers were changed at weekly intervals. The daily samples record short-term changes in radioactivity, while the weekly samples are used to compare onsite and offsite activities. High radioactivity on the site is indicative of radioactivity released by Argonne if the difference between this radioactivity and normal background is greater than the 10 to 20 percent error in sampling and counting. The alpha and beta radioactivity in air-filter samples are summarized in table 1; the average concentration of gamma-ray emitters as determined by gamma ray spectrometry are summarized in table 2.

During the second half of the year, the gamma-ray spectra were obtained with a large volume, high resolution, shielded, lithium-drifted germanium detector. This counting system improved the sensitivity by a factor of 10 over the sodium iodide detector previously used. Because of this difference in sensitivity, no meaningful annual averages could be calculated for some nuclides, as indicated in table 2.

The activities were very similar on and off the site, indicating that Argonne did not add significantly to the air-borne particulate activity of the environment during the year, and that the activities originated in a widespread source, such as fallout from nuclear test detonations or naturally-occurring materials, and not in a localized source, such as the laboratory.

The alpha radioactivity concentrations were normal and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium-7, produced in the stratosphere by cosmic-ray interactions. The concentrations of total beta radioactivity and of all the gamma-ray emitters for which positive results were obtained, increased steadily from January to June, then decreased during the remainder of the year. This variation can be attributed to the increased stratospheric fallout usually observed in the spring.

Since the fission product concentrations varied in approximately the same manner as beryllium-7, except that they decreased at a greater rate during the latter part of the year through radioactive decay, the bulk of the fission products was also derived from the stratosphere. The presence of the fission products can be correlated with announced nuclear tests. The average beta radioactivity for the year, 0.27 pCi/m^3, was about 15 percent higher than in 1969. The bulk of this increase occurred during the second quarter and was principally due to the increased concentrations of intermediate half-life fission products, notably zirconium-niobium-95 and cerium-144. Because iodine-131 and barium-140 were not detected before the appearance of the zirconium-niobium-95 and

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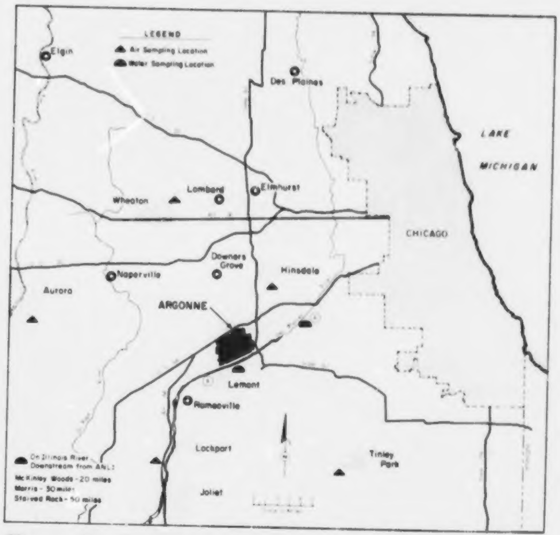
LEGEND
Air Sampling Location
Water Sampling Location
Elgin
Des Plaines
LAKE
MICHIGAN
Wheaton
Lombard
Elmhurst
CHICAGO
Downers Grove
Hinsdale
Naperville
Aurora
ARGONNE
Lemont
Romeoville
Lockport
Tinley Park
Joliet
On Illinois River Downstream from ANL:
McKinley Woods - 20 miles
Morris - 30 miles
Starved Rock - 50 miles

Figure 2. Location of Argonne National Laboratory (including some offsite sampling locations)

cerium-144, the implication is that the latter fission products came from the stratosphere. The detection of short-lived fission products, such as iodine-131, barium-140, and ruthenium-103 at all sampling locations during the last quarter of the year indicates the presence of fission products of recent origin.

Additional measurements made on the air-filter samples showed that small amounts of cobalt-60 were present in some of the samples collected since August outside building 310 in the 300 area. The maximum concentration in any one weekly sample (collected in December) was 0.01 pCi/m^3, 0.0001 percent of the AEC standard. Radiocobalt was not detected in any of the other air-filter samples, on or off the site. Work is performed in several buildings of the 300 area with a variety of radioactive materials, including fission and neutron activation products. The concentrations of fission products in the building 310 air-filter samples, however, remained the same as in samples collected elsewhere. The precise origin of the cobalt-60 has not yet been established.

Precipitation collected on the site contained the same fission products found in the air samples.

Composite monthly precipitation samples were also analyzed for iron-55. The average monthly concentrations ranged from 2.7 in February to 400 pCi/m^2 in April. The average for the year, 60 pCi/m^2 was a factor of three less than the 1969 average. Iron-55 is a neutron activation product and was produced mainly in nuclear tests conducted in September and October 1961. Therefore, the above concentrations have been corrected for decay to October 15, 1961, for comparison purposes.

Air sampling for argon-41, a beta-particle emitter with a 1.8 hour half-life that is produced in an operating reactor by the action of neutrons on the stable argon-40 in air, was conducted near the Juggernaut reactor (building 335) from January through April, and near the CP–5 reactor (building 330) from October to December. Between May and September neither reactor was in operation. The results are tabulated in table 3. Since the samples were collected downwind from the reactor after it had been in operation for several hours, the actual average concentration in the 300 Area was less than the values in the table.

The average and maximum concentrations of 82 and 2,230 nCi/m^3 are, respectively, about 2.1 and 56 times the AEC standard for uncontrolled areas and 0.04 and 1.1 times the AEC

Table 3. Argon-41 concentrations, 300 Area, October-December 1970

Month (1970)	Number of samples	Number of samples >20 nCi/m^3	Concentration[a] (nCi/m^3)		Percent of AEC standard	
			Average	Maximum	Average	Maximum
October	38	7	61	590	150	1,480
November	38	13	200	2,230	500	5,580
December	36	15	215	1,540	540	3,850
Annual summary	233	66	82	2,230	205	5,580

[a] Minimum detectable concentration—20 nCi/m^3.

standard for controlled areas. In this case, comparison with the AEC standards for controlled areas is appropriate since the sampling was conducted on the site.

The argon-41 concentration in the exhaust air from the Juggernaut was about 2.6 × 10^5 nCi/m^3, so the average dilution by outside air, based on the average of 25 nCi/m^3 for samples collected for the first 4 months of 1970, was about a factor of 10^4. The argon-41 concentrations measured in the vicinity of the CP–5 reactor (Building 330), which operates at a power level about 20 times higher than the Juggernaut, during the last 3 months of 1970 was 158 nCi/m^3. In the CP–5 reactor the air that is exposed to neutrons is diluted with a large volume of inactive air before it is discharged. This means that the argon-41 concentrations in the air leaving the two reactor buildings are not greatly different, although the volume of air (containing argon-41) is about 15 times greater from CP–5. As a result, the argon-41 concentration in outside air averaged only six times greater near the CP–5 reactor, although the argon-41 production is about 20 times greater.

Air was sampled for tritiated (hydrogen-3) water vapor, near the CP–5 reactor. The results are given in table 4. The results were positive in all cases, although the concentrations were well below the AEC standards. This nuclide is produced continuously by several methods while the reactor is in operation.

In CP–5 the largest source is by neutron irradiation of the heavy water used for cooling and neutron moderating. The average concentration, 286 pCi/m^3, was about 30 percent lower than in 1969. Samples were also collected twice a month in the east area, 2,000 yards from the reactor. In these samples the tritium concentration ranged from 1.2 to 37 pCi/m^3 and averaged 12 pCi/m^3. The east area samples generally varied in the same manner as the activity in the samples near CP–5 when the prevailing wind direction and velocity were considered. In general, east area samples were greater than 10 pCi/m^3 on days when samples at CP–5 were greater than 100 pCi/m^3 and the wind was from the southwest. The correlation is sufficiently good to conclude that most of the tritium in the east area came from CP–5. In addition, samples were collected twice a month from a control point located about 6 miles off the laboratory site. The tritium concentration in these samples ranged from 1.4 to 13 pCi/m^3 and averaged 5.6 pCi/m^3. No correlation between high results at CP–5 and offsite results could be determined. Although the reactor did not operate the first 9 months of 1970 due to rehabilitation, the heavy water, containing the long-lived tritium (12.3-year half-life) at a concentration of 1.5 × 10^9 pCi/ml, was handled and evidently small quantities escaped from the building.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a small stream that runs through the Argonne grounds and flows into the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled upstream from the Argonne site and downstream from the wastewater outfall to determine if radioactivity was added to the

Table 4. Tritium concentrations in air, July-December, 1970

Month	300 area						East area				Offsite			
	Number of samples	Concentration (pCi/m^3)			Percent of AEC standard		Number of samples	Concentration (pCi/m^3)			Number of samples	Concentration (pCi/m^3)		
		Avg	Min	Max	Avg	Max		Avg	Min	Max		Avg	Min	Max
July	43	452	18	2,680	0.22	1.34	1			31	1			6.3
August	32	556	10	2,510	.28	1.26	2	24	16	32	2	12	10	13
September	26	319	4.5	1,590	.16	0.79	2	16	14	18	2	3.8	3.0	4.6
October	26	160	2.2	1,240	.080	0.62	2	4.2	3.3	5.1	2	6.4	3.7	9.0
November	24	201	5.4	980	.10	0.49	2	21	4.6	37	2	3.6	2.5	4.8
December	24	94	1.2	433	.047	0.22	2	4.7	1.2	8.1	2	2.1	1.4	2.8
Annual summary	326	286	1.2	4,730	1.14	2.37	11	12	1.2	37	11	5.6	1.4	13

Table 5. Nonvolatile alpha and beta radioactivity in Sawmill Creek water Argonne National Laboratory, July-December 1970

Month	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	2	5.8	2.7	8.8	27	18	36
	Downstream	24	1.7	1.2	2.6	14	11	18
August	Upstream	2	4.0	3.2	4.7	29	24	34
	Downstream	20	1.8	1.2	2.1	18	14	22
September	Upstream	2	3.3	1.8	4.8	19	15	23
	Downstream	19	1.8	1.5	2.1	14	12	17
October	Upstream	2	3.5	1.1	5.8	22	12	31
	Downstream	21	1.3	.46	2.8	12	11	13
November	Upstream	2	1.0	.84	1.2	9.6	9.4	9.8
	Downstream	18	1.7	1.4	2.0	10	10	11
December	Upstream	2	1.3	.86	1.8	9.5	8.6	10
	Downstream	23	1.8	.76	2.4	9.4	7.5	11
July-December summary	Upstream	12	3.2	0.84	8.8	19	8.6	36
	Downstream	125	1.7	.46	2.8	13	7.5	22

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

stream in Argonne wastewater. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was sampled three to five times weekly. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the individual samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected twice monthly and at least one sample each month was analyzed for each radionuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during July–December 1970 are given in table 5. Upstream from the Argonne site, the alpha activity was due primarily to radionuclides that occur naturally in the stream. Any additional activity downstream would indicate a detectable contribution from Argonne wastewater.

Although Argonne wastewater contained a small quantity of alpha activity, the results show that its addition to the creek did not increase the total alpha activity in the stream. Beginning in November, all water samples were filtered to remove suspended solids. This treatment reduced the alpha and beta activities appreciably, particularly in above-site Sawmill Creek and Des Plaines River samples, which contain suspended soil with its accompanying natural uranium and thorium.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in Sawmill Creek water due to these elements is summarized in table 6. The concentrations were low compared to the AEC standards.

The uranium content attributable to Argonne below the outfall ranged from 0.7 to less than 0.1 pCi/liter, depending on the relative

Table 6. Alpha-emitting elements in Sawmill Creek water Argonne National Laboratory, July-December 1970

Element	Location[a]	Number of samples	Concentration[b] (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Uranium	Upstream	6	1.4	0.84	2.0	0.004	0.005
	Downstream	57	1.4	.74	2.0	.004	.005
Plutonium	Upstream	5			<.05		<.001
	Downstream	55	.058	<.05	.36	.001	<.007
Thorium	Upstream	6	<.05	<.05	.08	<.003	.004
	Downstream	55	<.05	<.05	.06	<.003	.003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

amounts of natural creek and wastewater, about the same as during 1969. The amount of uranium in the wastewater, however, was too low to increase the total uranium concentration in the creek water. The thorium concentrations were normal at both locations. Small amounts of plutonium were found in a few below-outfall samples, and this plutonium evidently was added in Argonne wastewater.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The normal nonvolatile beta radioactivity is approximately 5 pCi/liter above the site and 3 to 5 pCi/liter below the site, depending on the amount of dilution by wastewater. It is estimated that fallout activity added about 10 pCi/liter to the nonvolatile beta radioactivity at both locations (fallout is added to the water below the outfall directly from the air as well as by above-site water) and the Argonne contribution below the outfall averaged 1 pCi/liter. The Argonne contribution decreased to one-half of the 1969 levels, while the fallout contribution remained about the same.

The results of analysis of Sawmill Creek water for specific beta-emitting nuclides are summarized in table 7. The principal bèta-particle emitter added to the creek by Argonne wastewater was tritium. About 80 percent of this nuclide below the outfall resulted from laboratory operations. Since this radionuclide is present as water (HTO), it is not included in the total nonvolatile beta activity in table 5. Separate samples were analyzed specifically for tritium. Although small amounts are produced by cosmic-ray interactions with the atmosphere, the bulk of the tritium in above-site water originated in nuclear detonations. The iodine-131 found below the outfall is believed to be due to fallout since this radionuclide was also widely present in air at the same time. Although some of the other nuclides listed were also added to the creek by fallout, the total concentration, regardless of source, must be used in assessing the health hazard of a radionuclide not naturally present in the environment. The percent of the AEC standard given in the table was calculated on this basis. As indicated in the table, the beta activities in the creek were very low compared to the AEC standards.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled once a month above the mouth of Sawmill Creek and twice a month below the mouth to determine if the radioactivity in the creek has any effect on the radioactivity in the river. The total radioactivity is summarized in table 8, and the results of analysis for specific elements and radionuclides are given in table 9. In

Table 7. Beta-emitting radionuclides in Sawmill Creek water
Argonne National Laboratory, July-December 1970

Radionuclide	Location[a]	Number of samples	Beta radioactivity[b] (pCi/liter)			Percent of AEC standard	
			Average	Minimum	Maximum	Average	Maximum
Barium-Lanthanum-140	Upstream	6			<2		<0.007
	Downstream	57			<2		<.007
Cesium-137	Upstream	3			<.5		<.003
	Downstream	57			<.5		<.003
Tritium	Upstream	6	450	<200	660	.015	.022
	Downstream	125	1,400	460	6,000	.047	.20
Iodine-131	Upstream	1			<3		<1
	Downstream	125	<3	<3	6.1	<1	2.0
Strontium-89	Upstream	6			<2		<.07
	Downstream	57			<2		<.07
Strontium-90	Upstream	6	1.2	.54	1.5	.40	.50
	Downstream	57	1.4	.93	2.1	.47	.70
Technetium-99	Upstream	3			<.5		<.0002
	Downstream	57			<.5		<.0002

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).
[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

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Table 8. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory July-December 1970

Location	Concentration (pCi/liter)			
	Nonvolatile alpha radioactivity	Uranium	Nonvolatile beta radioactivity	Tritium
Des Plaines River[a] (above Sawmill Creek)	[b]2.3 (6)	1.5 (2)	14 (6)	440 (3)
Des Plaines River[c] (below Sawmill Creek)	3.2 (12)	1.5 (6)	16 (12)	460 (12)
Illinois River[d]	.89 (3)	.67 (1)	7.7 (3)	330 (1)

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Number in parenthesis is number of samples.
[c] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[d] Sampled at McKinley Woods State Park, Morris and Starved Rock State Park.

contrast to previous years, the concentration of tritium in the Des Plaines River below the mouth of Sawmill Creek was not measureably higher than above Sawmill Creek.

The concentrations of the other radionuclides and the total alpha and beta radioactivities were in their normal ranges at both locations. The annual average beta radioactivity (15 pCi/liter) was about the same as in 1969. The natural nonvolatile beta radioactivity in the river is 5 to 10 pCi/liter, and the excess (about 7 pCi/liter) was due to fallout. The total radioactivity in samples of Illinois River water was similar to those found in other bodies of water in the area and to activities found previously at these same locations. No radioactivity originating from Argonne could be detected.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Iodine-131 was not present in concentrations greater than the minimum detectable amount of 20 pCi/liter. Barium-140 was detected in the November milk sample at a concentration of 1.7 pCi/liter, while the strontium-89 concentration was 4.7 pCi/liter in this sample and 1.9 pCi/liter in the December sample. The cesium-137 and strontium-90 concentrations are given in table 10. All the fission products originated in nuclear tests and their presence in milk is not related to Argonne operations. The average strontium-90 content changed little from last year, while the cesium-137 concentrations were about 35 percent lower.

Conclusion

Argonne's contribution to the environmental radioactivity was primarily limited to tritium and argon-41 in the air and to tritium in water

Table 9. Radioactivity in Des Plaines River water Argonne National Laboratory, July-December 1970

Radionuclide	Location[a]	Number of samples	Concentration[b] (pCi/liter)		
			Average	Minimum	Maximum
Barium-lanthanium-140	Upstream	0			
	Downstream	0			
Cesium-137	Upstream	0			
	Downstream	3			<0.5
Tritium	Upstream	3	440	360	500
	Downstream	12	460	<200	690
Plutonium (alpha)	Upstream	2			<.05
	Downstream	6			<.05
Strontium-89	Upstream	1			<2
	Downstream	2			<2
Strontium-90	Upstream	1			1.4
	Downstream	2	1.5	1.5	1.6
Technetium-99	Upstream	0			
	Downstream	3			<.05
Thorium	Upstream	2	.06	<.05	.10
	Downstream	6	.05	.05	.12
Uranium (alpha)	Upstream	2	1.5	1.3	1.7
	Downstream	6	1.5	.85	2.0

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).
[b] For averaging purposes, individual sample results that were less than the minimum detectable concentration were assumed to be one half of the minimum detectable concentration.

from Sawmill Creek. The only activity detected off the site was tritium in Sawmill Creek. Fallout from nuclear detonations continued to be the principal source of non-natural radioactivity in the environment and occurred at about the same level as during 1969.

Table 10. Fission product concentration in milk July-December 1970

Date collected	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
July 1	20	11.3
August 5	10	7.7
September 2	<10	6.7
October 7	20	7.0
November 10	15	6.6
December 2	<10	8.3
Average	14	7.9

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July-December 1969	January 1971
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Reported Nuclear Detonations, December 1971

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission conducted one underground nuclear test at its Necada Test Site on December 14, 1971. It was in the low-intermediate yield range (20-200 kilotons TNT equivalent).

Seismic signals were recorded by the United States on December 22, 1971, presumably from a Soviet underground nuclear explosion. The signals originated north of the Caspian Sea and were equivalent to those of an underground nuclear explosion in the yield range of 200 kilotons-one megaton.

The U.S. Atomic Energy Commission announced that on December 30, 1971, the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals, which originated in the Semipalatinsk nuclear test area, were equivalent to those of an underground nuclear explosion in the low-intermediate yield range of 20-200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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Correction:

The following footnote was inadvertently left out of the report entitled "A Joint X-ray Radiation Survey in Puerto Rico, 1968" by Michael Gileadi:

[2] The responsibility for radiation protection and control (associated with the use of radiation in medicine, education and commerce in Puerto Rico) rests with the Radiological Health Program in the Department of Health of the Commonwealth of Puerto Rico.

The article appeared on page 495 of the October 1971 issue of Radiological Health Data and Reports, and the footnote refers to the end of the first paragraph of the article.

RADIATION DATA AND REPORTS

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Volume 13, Number 2, February 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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Reports

Evaluation of Tritium in Ground and Surface Waters of the Western United States, April 1968-December 1969

James W. Mullins and John L. Stein[1]

In order to establish a baseline for environmental tritium so that any future deviations could be evaluated, a study was conducted to measure current levels of tritium in ground and surface waters of the Western United States. Data are reported for tritium concentrations in surface and ground waters during April 1968-December 1969 in the Western United States including Alaska and Hawaii. Samples were collected by State public health agencies and mailed to the Western Environmental Research Laboratory where they were analysed by liquid scintillation techniques. The concentration of tritium was nondetectable in most ground water samples, while other samples contained as much as 2.6 nCi/liter. Surface water samples ranged from nondetectable to 3.8 nCi/liter. Possible reasons for the range of results, such as altitude and latitude effects, are discussed.

A preliminary study of tritium in surface water was conducted in 1963 to determine the levels of tritium in raw and treated waters collected through the Water Pollution Surveillance Program of the Division of Water Supply and Pollution Control and by the Institutional Total Diet Sampling Program of the Division of Radiological Health, U.S. Public Health Service. Observed tritium concentrations in surface waters varied from nondetectable to 12 nCi/liter (*1*).

Based on these and other findings, a surveillance program was established in May 1964 to measure tritium concentrations in 10 major rivers of the United States. Eight of these stations were downstream from nuclear facilities and two served as baselines. This program was administered by the Eastern Environmental Radiation Laboratory[2] (EERL), Environmental Protection Agency (*2*). Observed tritium concentrations ranged from less than detectable to 32 nCi/liter. The results from this program have been reported periodically in *Radiological Health Data and Reports.*

Purpose and scope

The purpose of this study was to gather data on current levels of tritium in ground and surface waters of the Western United States. The study was necessary to establish the baseline concentration level for environmental tritium, so that future deviations from the baseline could be evaluated.

The study was conducted by the Western Environmental Research Laboratory[3] (WERL), U.S. Environmental Protection Agency. At the initiation of the study, all States west of the Mississippi River, including Alaska and Hawaii, were contacted in order to gain their assistance in locating the actual sampling points and the collection of samples. Although surface waters were of principal interest, it was left to the discretion of the various State public health and atomic energy agencies whether or not any ground water samples would be collected. Maps showing the locations of the surface and ground water sampling stations selected are shown in figures 1 and 2, respectively.

---

[1] Mr. Mullins is and Mr. Stein was with the Technical Services and Environmental Surveillance Programs, Western Environmental Research Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nev. 89114. Mr. Stein is now with the Anheuser-Busch Company, St. Louis, Mo.

[2] Formerly the Southeastern Radiological Health Laboratory of the Public Health Service but renamed the Eastern Environmental Radiation Laboratory following its transfer from the Public Health Service to the U.S. Environmental Protection Agency.

[3] Formerly the Southwestern Radiological Health Laboratory of the Public Health Service but renamed the Western Environmental Research Laboratory following its transfer from the Public Health Service to the U.S. Environmental Protection Agency on December 2, 1970.

Procedures

Sample collection procedures were set up to provide quarterly samples during 1968 and 1969. In some cases, stations were sampled only once with new stations selected for subsequent sampling. In other cases, composite samples collected over a period of a month were obtained instead of single grab samples. All sample collection was carried out by State agencies which then forwarded the samples to WERL or EERL for analysis. The first samples were collected in April 1968 and the program was terminated in December 1969.

All samples were purified by distillation and analyzed by liquid scintillation counting as described by Moghissi, et al. (*3*). The minimum detectable concentration (MDC) at WERL is 400 pCi/liter based on 5 ml of sample and 100-minute counting time. The estimated analytical error, based on the 3σ counting error, is 400 pCi/liter for results up to 4 nCi/liter and 10 percent of the measurement above that amount. The MDC at EERL is 200 pCi/liter based on a 5 ml sample size and 200-minute counting time.

Results

A summary of the results for the various sampling stations in the study is presented in table 1. Surface water samples were received from all States participating in the study. Samples were collected from principal streams and various tributaries of the major river basins of the Western United States. Also sampled were numerous lakes and reservoirs. Ground water samples were obtained from the States of

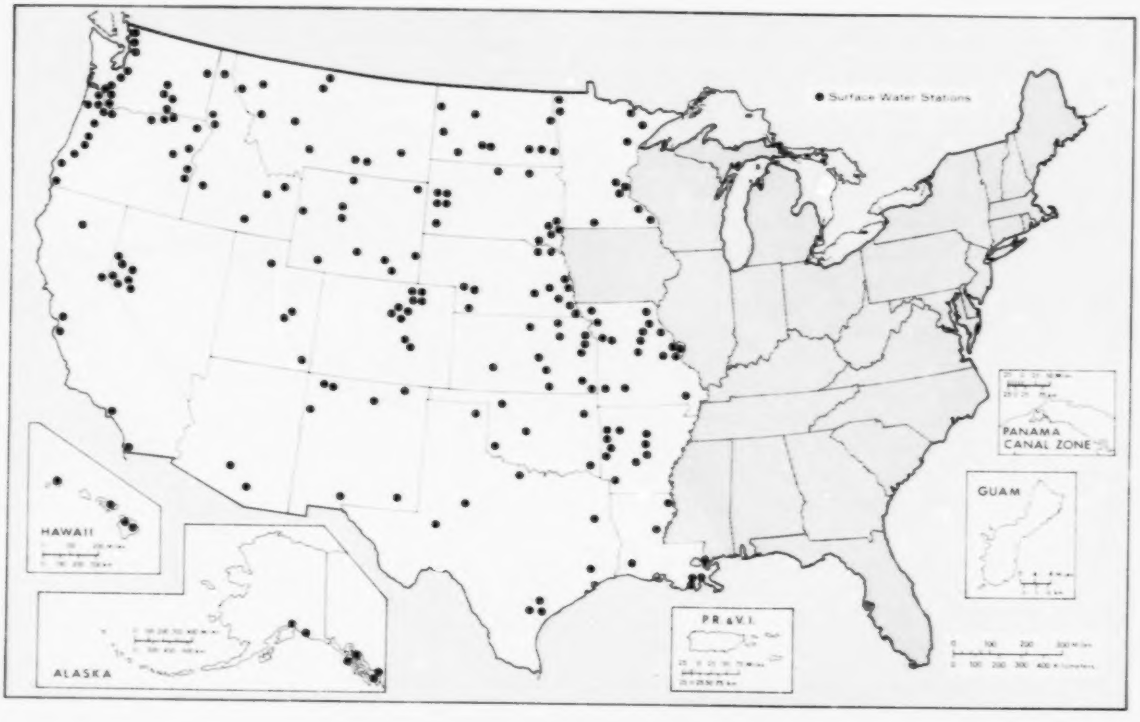

Figure 1. Surface water stations

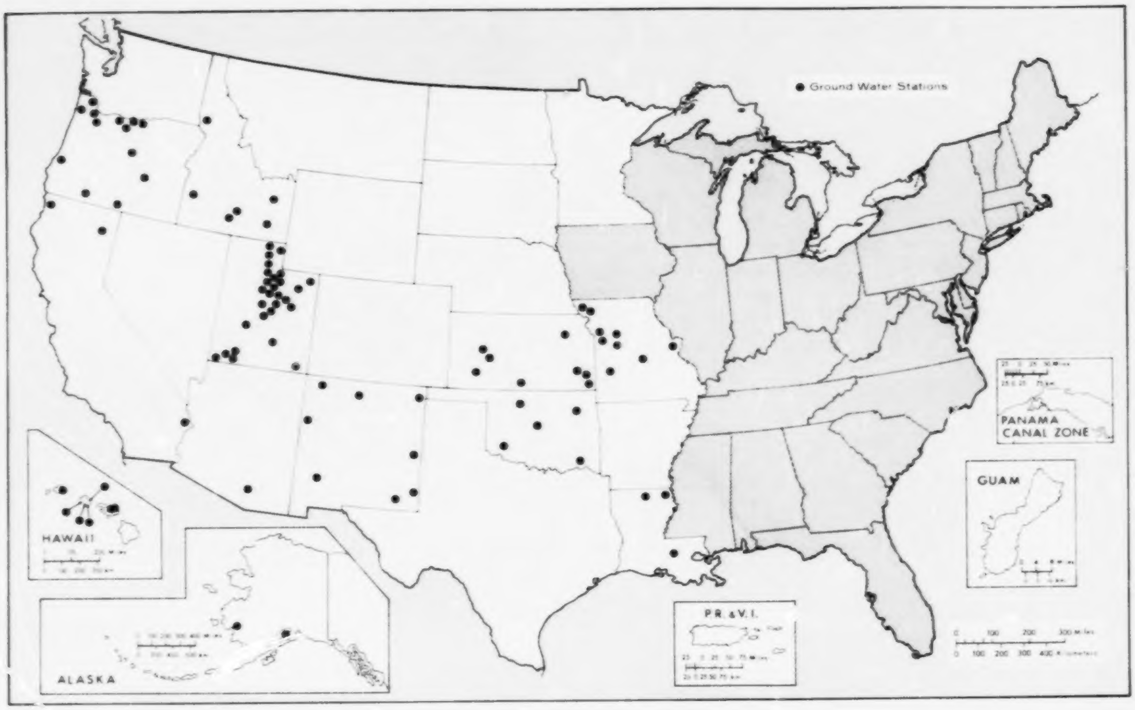

Figure 2. Ground water stations

Alaska, Arizona, California, Hawaii, Idaho, Louisiana, Kansas, Missouri, New Mexico, Oklahoma, Oregon, and Utah. All ground water samples came from wells, springs, or underground catchment systems.

In general, surface waters tended to indicate tritium levels above the MDC. The range of tritium concentrations for all surface samples was <MDC to 3.8 nCi/liter.

Most of the ground water samples showed tritium concentrations below the MDC, however, several samples did show detectable concentrations, one as high as 2.6 nCi/liter. Nearly all States showed at least one station above the MDC. In some cases, samples were taken from distribution systems which have some supply from surface sources. In other instances, samples came from shallow wells which are in close proximity to surface streams which indicated detectable levels of tritium. In this report, no attempt has been made to determine the source of tritium in ground waters.

For purposes of averaging, all values below detectable levels were considered to be zero. For this reason some averages are reported which are below the stated MDC.

Discussion of results—surface water samples

All surface water sample results for each State sampled in the 1968–1969 time period were averaged. Data for 1968 only were available for the States of Arkansas, Louisiana, and Oklahoma. The States were then classified into four categories based upon the average tritium concentration. The map in figure 3 shows the States in the study shaded to indicate the average tritium levels.

Examination of figure 3 discloses that the highest average levels of tritium in surface water occurred in the Mountain States (Colorado, Montana, Utah, and Wyoming) and in the Northern Plains States (Minnesota, North Dakota, and South Dakota). Lesser average concentrations are noted in the bordering States of Idaho and Nebraska. Intermediate levels are found in States still further from the areas of maximum average concentrations; States with intermediate levels are California, Missouri,

Table 1. Tritium concentrations in water samples, April 1968 to December 1969

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Alaska:					
Bethel: Public Health Service hospital	Well	11	<400	<400	0
Chugiak: Peters Creek	Stream	11	1,700	770	1,100
Cordova	Reservoir	9	820	<400	390
Juneau	Reservoir	3	<400	<400	0
Ketchikan: 1287 Tongass Avenue	Lake	1	—	—	510
628 Park Avenue	Lake	1	—	—	0
Sitka: Indian River	Stream	1	—	—	0
Soldotna: Ground source	Well	11	600	<400	90
Arizona:					
Phoenix: Encanto Park golf course	Stream	4	<400	<400	0
Fire Station, 230 E. Roeser Road	Stream	4	<400	<400	0
Squaw Peak Treatment Plant	Stream	4	710	<400	180
21st Avenue and Morton	Stream	4	<400	<400	0
32nd Drive and Myrtle	Stream	4	<400	<400	0
48th Street and Virginia	Stream	4	<400	<400	0
Verde plant effluent	Stream	1	—	—	0
Tucson: Plant No. 1	Well	4	<400	<400	0
Plant No. 3	Well	4	<400	<400	0
Plant No. 4	Well	4	<400	<400	0
Arkansas:[a]					
Arkadelphia: Texaco station	Reservoir	2	400	200	300
Benton: Texaco station	Reservoir	2	400	<200	200
Conway: Stanton's Esso station	Reservoir	2	400	<200	200
Fort Smith: Sands Motel	Reservoir	2	400	200	300
Greenwood: Texaco station	Reservoir	2	400	200	300
Little Rock: Radiological Health Laboratory	Reservoir	2	400	300	350
Mena: Esso station	Reservoir	2	<250	<200	0
Russellville: Phillips 66 station	Reservoir	2	600	600	600
Texarkana: Texaco station	Reservoir	2	200	<200	100
Waldron: Citgo station	Reservoir	2	300	<200	150
California:					
Alturas	Well	6	<400	<400	0
Berkeley	Reservoir	6	570	<400	430
Crescent City	Well	6	<400	<400	0
Los Angeles	Stream/well	6	1,500	<400	250
Metropolitan Water District of Southern California Weymouth Treatment Plant	Stream	5	2,400	1,600	2,000
Needles	Well	6	1,700	<400	870
Redding	Reservoir	6	<400	<400	0
San Diego: Alvarado Treatment Plant	Stream	6	2,400	780	1,500
San Francisco	Reservoir	6	490	<400	230
Tahoe City: 50 miles SW	Lake	3	<400	<400	0
Colorado:					
Boulder: Boulder Creek at 75th Avenue	Stream	7	2,500	1,200	1,700
Eben Fine Park	Stream	7	1,600	1,000	1,300
Brighton: S. Platte River at Hwy. 224	Stream	7	1,600	950	1,200
Colorado Springs: Fountain Creek (above)	Stream	7	1,800	900	1,300
Fountain Creek (below)	Stream	7	1,400	850	1,200
Denver: S. Platte River at Bowles Avenue	Stream	6	1,400	836	1,200
Greeley: Cache La Poudre River	Stream	6	1,800	1,100	1,600
South Platte River at Hwy. 60	Stream	7	2,600	1,000	1,800
South Platte River at Hwy. 66	Stream	7	2,200	1,200	1,500
St. Vrain Creek at Hwy. 66	Stream	7	2,200	1,300	1,800
Hawaii:					
Honolulu: Airport	Well	5	<400	<400	0
Central	Well	5	<400	<400	0
Department of Health	Well	5	<400	<400	0
Kahului: Makuhau Storage	Well	5	<400	<400	0
Kamuela: Waikola Stream, 22 miles north	Stream	5	<400	<400	0
Kuaui Island: Port Allen pier	Well	5	<400	<400	0
Hilo: Pakamaui Storage	Reservoir	5	<400	<400	0
Lahaina: County System	Stream/well	5	<400	<400	0
Lihue: Pua Loke Park	Well	5	<400	<400	0
Pearl City: Hoomalu Street	Well	5	<400	<400	0
Idaho:					
Blackfoot: Public water supply		2	1,800	1,100	1,500
Springfield Lake, 30 miles SW	Lake	6	800	<400	340
Atomic City, 33 miles NW		5	450	<400	90
Boise: Boise River	Stream	6	1,100	660	880
Public water supply	Well	1	—	—	880
Buhl: Public water supply	Well	1	—	—	0
Burley: Snake River at Milner Dam	Stream	5	910	<400	600
Minidoka, 20 miles NE	Well	5	<400	<400	0
Idaho Falls: Snake River	Stream	6	1,100	570	900
Idaho Falls: Public water supply	Well	1	—	—	740
Jerome: Public water supply	Well	6	<400	<400	0
Lewiston: Clearwater River	Stream	1	—	—	1,200
Snake River	Stream	5	1,000	<400	460
Moscow: Public water supply	Well	6	<400	<400	0
Sandpoint: Pend Oreille Lake	Lake	5	1,500	1,000	1,300

See footnotes at end of table.

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Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Kansas:					
Baxter Springs: 6 miles SW	Well	1	—	—	0
Spring River	Stream	7	1,100	<400	250
Burlington: Neosho River, 27 miles SE	Stream	1	—	—	560
Cheney: Ninnescah River	Stream	6	750	<400	130
Dighton	Well	1	—	—	660
Dodge City: Arkansas River	Stream	7	720	<400	240
Garden City	Well	1	—	—	0
Glen Elder: Solomon River	Stream	7	840	<400	270
Harper	Well	1	—	—	0
Jetmore	Well	1	—	—	0
Langley: Smokey Hill River	Stream	1	—	—	0
Lecompton: Kansas River	Stream	6	1,100	<400	220
Manhattan	Well	1	—	—	580
Big Blue River	Stream	7	710	<400	100
Oketo: Big Blue River	Stream	7	890	<400	200
Ottawa: Marais des Cygnes River	Stream	6	530	<400	90
Parsons: Neosho River	Stream	7	880	<400	190
Riverton	Well	1	—	—	0
Walnut	Well	1	—	—	0
Winfield: Walnut River	Stream	7	610	<400	170
Louisiana:[a]					
Alexandria: Red River	Stream	1	—	—	300
East Baton Rouge: Well 19	Well	2	<200	<200	0
Farmerville: Well 3	Well	2	800	<200	400
Jonesville: Black River	Stream	2	800	<200	400
Kentwood: Wells	Well	1	—	—	0
Lake Charles: Calcasieu River	Stream	2	400	<200	200
New Orleans	Stream	1	—	—	400
	Stream	1	—	—	0
	Stream	1	—	—	300
Oak Grove: Well 1	Well	2	<200	<200	0
Slidell: West Pearl River	Stream	2	200	<200	100
Minnesota:					
Clearwater: Mississippi River	Stream	8	1,200	680	1,100
Grand Forks: Red Lake River	Stream	8	1,800	600	1,300
Eveleth: St. Mary's Lake	Lake	8	1,800	<400	1,400
Fairmont: Budd Lake	Lake	8	1,300	600	900
Hallock: South Fork, Two Rivers	Stream	8	1,200	<400	900
International Falls: Rainy River	Stream	7	2,700	1,400	2,000
Minneapolis: Mississippi River	Stream	7	1,200	610	1,000
Pine City: St. Croix River, 9 miles east	Stream	8	750	<400	230
Red Wing: Mississippi River at Lock & Dam 3	Stream	2	1,200	960	1,100
St. Paul: Vadnais Lakes	Lake	8	1,800	500	1,000
Winona: Mississippi River, 10 miles east	Stream	6	800	500	700
Missouri:					
Boonville: Public water supply	Stream	5	1,400	670	1,100
Carrollton	Well	1	—	—	0
Columbia		1	—	—	0
Concordia	Well	1	—	—	800
Eldorado	Well	1	—	—	0
Hannibal: New London public water supply	Stream	6	940	<400	160
Independence	Well	1	—	—	0
Jefferson City	Well	7	1,500	<400	360
Joplin: Public water supply	Stream	6	1,100	<400	180
Kansas City	Stream	5	1,400	<400	910
Grain Valley, 10 miles east	Stream	2	1,700	<400	850
Kirksville	Lake	7	970	<400	480
Macon	Lake	1	—	—	0
Maitland	Well	1	—	—	0
Maryville	Stream	1	—	—	0
Moberly	Lake	1	—	—	0
Mound City	Well	1	—	—	0
Platte City	Well	1	—	—	2,600
Poplar Bluff: Public water supply	Stream	6	<400	<400	0
Sedalia	Stream/well	1	—	—	690
Springfield: Public water supply	Lake	6	560	<400	90
St. Joseph	Stream	7	2,700	830	1,600
St. Louis	Stream	2	1,300	<400	650
St. Louis County	Stream	5	1,800	<400	850
Fenton, 10 miles south	Stream	1	—	—	0
Union	Stream/well	1	—	—	0
Montana:					
Bozeman: Bozeman Creek	Stream	8	1,700	640	1,100
Chinook: Milk River	Stream	8	1,800	1,000	1,400
Forsyth: Yellowstone River	Stream	8	3,500	1,100	1,800
Fort Benton: Missouri River	Stream	8	1,400	430	910
Hardin: Big Horn River	Stream	8	1,900	<400	1,200
Helena: Prickley Pear Creek	Stream	6	1,800	670	1,200
Kalispell: Flathead River	Stream	8	1,600	770	1,100
Laurel: Yellowstone River	Stream	8	1,700	750	1,200
Missoula: Rattlesnake Creek	Stream	8	1,200	<400	810
Noxon: Columbia River, Clark Fork	Stream	7	1,500	760	1,100

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Nebraska:					
Benkelman: Republican River	Stream	7	1,400	<400	200
Blair: Missouri River	Stream	6	2,200	870	1,700
Brownville: Missouri River	Stream	7	2,300	520	1,500
Crete: Big Blue River	Stream	6	560	<400	90
Niobrara: Niobrara River	Stream	7	<400	<400	0
Norfolk: Missouri River, 59 miles north	Stream	7	2,200	<400	1,400
North Platte: North Platte River	Stream	7	1,700	<400	580
Ogallala: South Platte River, 20 miles west	Stream	7	1,400	<400	660
Omaha: Missouri River	Stream	7	2,400	960	1,800
Rulo: Missouri River	Stream	7	2,100	550	1,500
Schuyler: Platte River	Stream	7	830	<400	210
St. Paul: North Loup River	Stream	7	560	<400	140
Nevada:					
Minden: Carson River, 10 miles SW	Stream	6	510	<400	170
Carson River, East Fork at Hatchery	Stream	6	560	<400	170
Reno: Steamboat Ditch, 15 miles south	Stream	6	<400	<400	0
Verdi: Truckee River, SW of Ceresola Ranch	Stream	6	<400	<400	0
Truckee River, SW of Farad, Calif	Stream	6	<400	<400	0
Truckee River, SW of Lockwood	Stream	6	<400	<400	0
Wabuska: Walker River at J & J Ranch	Stream	6	480	<400	150
Weeks: Carson River	Stream	6	480	<400	240
Yerington: Walker River, West Fork	Stream	6	520	<400	240
Walker River, East Fork	Stream	6	570	<400	170
New Mexico:					
Carlsbad: Pecos River	Stream	2	<400	<400	0
Public water supply	Well	7	<400	<400	0
Clayton	Well	6	<400	<400	0
Clovis	Well	7	<400	<400	0
Espanola: Public water supply	Well	7	<400	<400	0
Rio Grande	Stream	1	—	—	590
Farmington:	Well	3	1,800	1,400	1,600
Animas River	Stream	3	980	660	850
San Juan River	Stream	2	1,300	500	900
Gallup: Well Field	Well	7	<400	<400	0
Rio Puerce	Stream	1	—	—	570
Hobbs	Well	5	<400	<400	0
Las Cruces: Public water supply	Well	1	—	—	0
Rio Grande	Stream	7	780	<400	350
Raton: Cimarron River, 64 miles SW	Stream	1	—	—	1,100
Silver City	Well	7	<400	<400	0
North Dakota:					
Bismarck: Missouri River	Stream	5	2,200	1,300	1,800
Fargo: Red River	Stream	5	1,900	1,100	1,500
Grand Forks: Red River	Stream	5	1,500	1,200	1,300
Jamestown: James River Dam	Stream	5	2,000	840	1,200
Mandan: Heart River	Stream	5	1,400	1,000	1,200
Medora: Little Missouri River	Stream	4	1,400	<400	900
Minot: Souris River	Stream	5	1,900	500	1,500
Regent: Cannonball River	Stream	4	1,100	<400	690
Valley City: Sheyenne River	Stream	5	1,100	520	840
Williston: Missouri River	Stream	4	1,500	<400	710
Oklahoma:[a]					
Altus: Water Department	Lake	1	—	—	300
Blair	Well	1	—	—	0
Broken Bow	Stream	1	—	—	0
Enid	Well	1	—	—	0
Fort Supply	Lake	1	—	—	0
Jenks	Well	1	—	—	200
Nichols Hills	Well	1	—	—	0
Oklahoma City: Lake Heffner	Lake	1	—	—	0
Tulsa	Lake	1	—	—	0
Valliant	Well	1	—	—	0
Oregon:					
Albany: Santiam River, 7 miles north	Stream	1	—	—	0
Baker: Powder River	Stream	3	710	570	650
Bonneville: Bonneville well	Well	2	750	450	600
Brookings: Rogue River, 31 miles north	Stream	1	—	—	0
Columbia City: St. Helen's well	Well	2	710	570	640
The Dalles: Columbia River	Stream	1	—	—	970
Chenowith Irrigation District	Well	1	—	—	0
Mark s well	Well	2	650	<400	330
Elgin: Grande Ronde River	Stream	3	660	<400	440
Elkton: Umpqua River	Stream	1	—	—	0
Goble: Columbia River	Stream	1	—	—	750
Hines: Ed Hines mill	Well	1	—	—	0
Hood River: Graham's well	Well	2	660	660	660
John Day: John Day River	Stream	2	430	<400	220
Klamath Falls: Wagnor's well	Well	1	—	—	0
Lakeview: Lakeview well	Well	1	—	—	0
Myrtle Point: Coquille River, North Fork	Stream	1	—	—	0

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Oregon: continued					
North Bend: Douglas Fir Chip	Well	1	—	—	540
Ontario: Malheur River	Stream	2	530	<400	270
Snake River	Stream	3	660	570	610
Portland: Columbia River	Stream	1	—	—	620
Willamette River	Stream	1	—	—	0
Bull Run Headworks Reservoir No. 1	Lake	1	—	—	500
Columbia School	Well	2	<400	<400	0
Portland Rendering Company	Well	1	—	—	0
Prineville: Lamanta well	Well	1	—	—	0
Springfield: McKenzie River	Stream	1	—	—	0
Willamette: Public water supply	Stream	1	—	—	0
Tillamook: Fairview Water District	Well	1	—	—	440
Wilson River	Stream	1	—	—	0
Umatilla: Columbia River	Stream	1	—	—	1,100
Umatilla River	Stream	1	—	—	880
South Dakota:					
Aberdeen: James River, 35 miles NE	Stream	6	1,300	<400	900
Hot Springs: Cheyenne River, 21 miles SW	Stream	4	1,500	610	1,100
Mobridge: Missouri River	Stream	6	2,100	1,400	1,900
Rapid City: Rapid Creek at Johnson Siding	Stream	3	1,700	1,000	1,400
Rapid Creek, 18 miles SE	Stream	6	1,500	<400	1,000
Cheyenne River, 40 miles east	Stream	5	1,700	<400	1,100
Rapid Creek at Poctola Reservoir	Stream	3	1,600	<400	900
Sioux Falls: Big Sioux Path north	Stream	6	900	<400	610
Big Sioux Path south	Stream	6	1,400	650	920
Big Sioux, 70 miles SE	Stream	4	600	<400	150
Missouri River, 70 miles SE	Stream	5	2,000	<400	1,400
Yankton: James River, 5 miles east	Stream	5	2,700	680	1,400
Texas:*					
Colorado City: Colorado River	Stream	7	<200	<200	0
Conroe: San Jacinto River	Stream	7	<200	<200	0
Girwin: Pecos River	Stream	6	<200	<200	0
Goliad: San Antonio River	Stream	4	<200	<200	0
Port Neches	Stream	7	<200	<200	0
Refugio: Mission River	Stream	7	<200	<200	0
Tilden: Nueces River	Stream	7	<200	<200	0
Wichita Falls: Red River	Stream	6	<200	<200	0
Lower Gulf Coast	Stream	2	<200	<200	0
Canadian River	Stream	6	<200	<200	0
Utah:					
Alton: Palmer residence	Spring	1	—	—	0
Blanding: Cliff Palace motel	Reservoir	1	—	—	1,100
Bluff	Well	1	—	—	0
Brigham City: Health Department	Spring/well	1	—	—	0
Castle Dale: Emery Courthouse	Reservoir	1	—	—	1,400
Cedar Fort: Cedar Fort school	Spring/well	1	—	—	0
Clear Creek: Jensen residence	Spring	1	—	—	0
Delta: Delta City building	Well	1	—	—	0
Duchesne: Duchesne Courthouse	Well	1	—	—	0
Elberta: Mitarai residence	Spring	1	—	—	0
Ephraim: Municipal swimming pool	Spring/well	1	—	—	1,100
Fairview: WW Trailer Park	Spring/well	1	—	—	590
Gunnison: City building	Spring	1	—	—	0
Heber: Olsen residence	Spring/well	1	—	—	0
La Verkin: Gateway Trailer Court	Spring	1	—	—	0
Milford: Hong Kong Cafe	Well	1	—	—	0
Mona: Phillips 66 station, Hwy 91	Spring	1	—	—	0
Nephi: Juab City building	Spring/well	1	—	—	0
Oakley: American station	Spring	1	—	—	0
Park City: Treasure Mountain Inn	Spring	1	—	—	0
Peterson: Richins residence	Reservoir/well	1	—	—	800
Price: Silvagni building	Reservoir/spring	1	—	—	0
Randolph: Rich Courthouse	Spring	1	—	—	0
Red Wash: Warehouse	Well	1	—	—	1,300
Santa Clara: Santa Clara mercantile	Spring	1	—	—	0
South Monroe: Jensen residence	Spring/well	1	—	—	2,100
Torrey: Smith residence	Spring	1	—	—	0
Tremonton: Lamb's Service station, 15 miles north	Spring	1	—	—	9
Virgin: Flanigan residence	Spring	1	—	—	0
Wanship: Spring Chicken Inn	Well	1	—	—	0
Washington:					
Bellingham: Whatcom Lake	Lake	6	1,100	<400	660
Kent: Cedar River, 25 miles east	Stream	4	470	<400	230
Kelso: Toutle River, 12 miles north	Stream	1	—	—	590
Longview: Columbia River	Stream	6	1,700	<400	710
Lewis River, 20 miles south	Stream	2	690	550	620
Mount Vernon: Skagit River	Stream	2	1,100	520	810
McNary Dam: Columbia River	Stream	5	1,400	460	910
Pasco: Columbia River	Stream	4	1,300	930	1,000
Snake River	Stream	3	750	500	600
Puyallup: Puyallup River	Stream	4	<400	<400	0
Richland: Columbia River, untreated	Stream	4	1,100	710	940
Columbia River, treated	Stream	3	1,300	1,000	1,200
Snohomish: Snohomish River	Stream	1	—	—	1,400
Spokane: Spokane River, 25 miles NW	Stream	6	1,400	610	830
Vancouver: Columbia River	Stream	5	920	700	860

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Wyoming:					
Alpine: Snake River	Stream	8	2,300	560	1,300
Green River: Green River	Stream	8	1,700	<400	1,300
Hulett: Belle Fourche River	Stream	8	1,700	<400	1,100
Kane: Big Horn River	Stream	8	2,100	1,100	1,500
Laramie: Laramie River	Stream	8	1,500	<400	1,100
Medicine Bow: Medicine Bow River	Stream	8	3,800	<400	1,100
Muddy Gap: Sweetwater River	Stream	8	1,600	520	1,000
Riverton: Big Wind River	Stream	8	1,900	1,000	1,500
Shoshone: Poison Creek	Stream	8	1,600	810	1,300
Torrington: North Platte River	Stream	8	1,600	<400	1,000

[a] Analyses performed at the Eastern Environmental Radiation Laboratory.

New Mexico, and Washington of the contiguous States, and Alaska. The lowest levels of tritium were observed in areas contiguous to those where intermediate values were noted. These States included Arkansas, Arizona, Kansas, Louisiana, Nevada, Oklahoma, Oregon, and Texas. In addition, very low levels of tritium in surface water were determined in samples from Hawaii.

The principal contributors of tritium in the environment are cosmic-ray fast neutron bombardment of nitrogen and atmospheric testing of nuclear and especially thermonuclear devices. Secondary contributors include various nuclear facilities. Although atmospheric testing of nuclear devices has almost ceased in recent years, this input is largely responsible for the levels of tritium noted in ground and surface waters (4).

The phenomenon which accounts for the higher tritium levels observed in the Mountain and Plains States is not fully understood. Previous studies have noted a latitude effect in which tritium concentrations in precipitation increase generally with increasing latitude. It has also been observed that surface stations at higher altitudes generally show somewhat higher levels of tritium (5).

It is known that cosmic-ray activity, including neutron activity, increases rapidly with altitude. It is not known, however, if variance in the natural production rate of tritium with change in altitude is solely responsible for the "altitude effect" observed.

One explanation for both the altitude and latitude effects is that evaporated surface ocean water provides a reservoir of low tritium con-

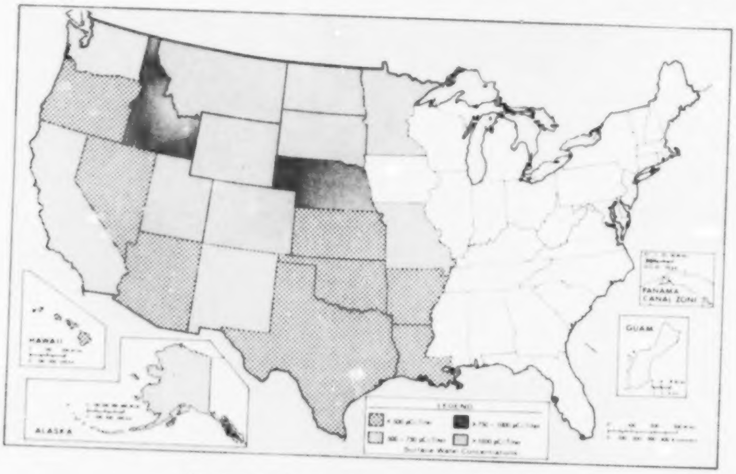

Figure 3. Surface water concentrations

tent atmospheric water vapor for dilution of tritium fallout. Hence, areas along the coasts would be likely to show lower tritium concentrations. Such vapor carried from the Gulf of Mexico across the Central and Eastern United States by prevailing winds might also serve to reduce concentrations in these areas. Inland mountain areas, however, would have no such opportunity for dilution (*6, 7*).

Other factors influencing tritium concentrations in water, such as seasonal variations of tritium concentration in precipitation, are known (*8*). However, no seasonal or precipitation correlations could be derived from this study.

Ground water samples

Generally, ground water from deep or geologically isolated aquifers does not contain measurable concentrations of tritium. Shallow wells may, however, show detectable levels. Tritium may reach such wells by percolation of rainwater or nearby surface waters which contain tritium. Less common sources of tritium in ground water are effluent from nuclear facilities and tracer studies.

In the majority of the stations sampled during the study, tritium was not detected. However, 17 widely scattered stations had one or more samples with detectable tritium.

Summary

Based upon this study of tritium in ground and surface waters of the Western United States, the following observations are made:

1. The concentration of tritium in ground water ranged from <MDC to 2.6 nCi/liter.
2. The concentration of tritium in surface water ranged from <MDC to 3.8 nCi/liter.
3. The majority of ground water samples did not show detectable tritium concentrations.
4. No tritium concentrations in individual samples were greater than 0.4 percent of the applicable radiation protection standard as recommended by the National Council on Radiation Protection and Measurements (*9*).

Acknowledgement

The assistance of the various State agencies cooperating in this study through the selection of sampling sites, the collection of samples, and the verification of basic data is gratefully acknowledged.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, October 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, U.S. Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

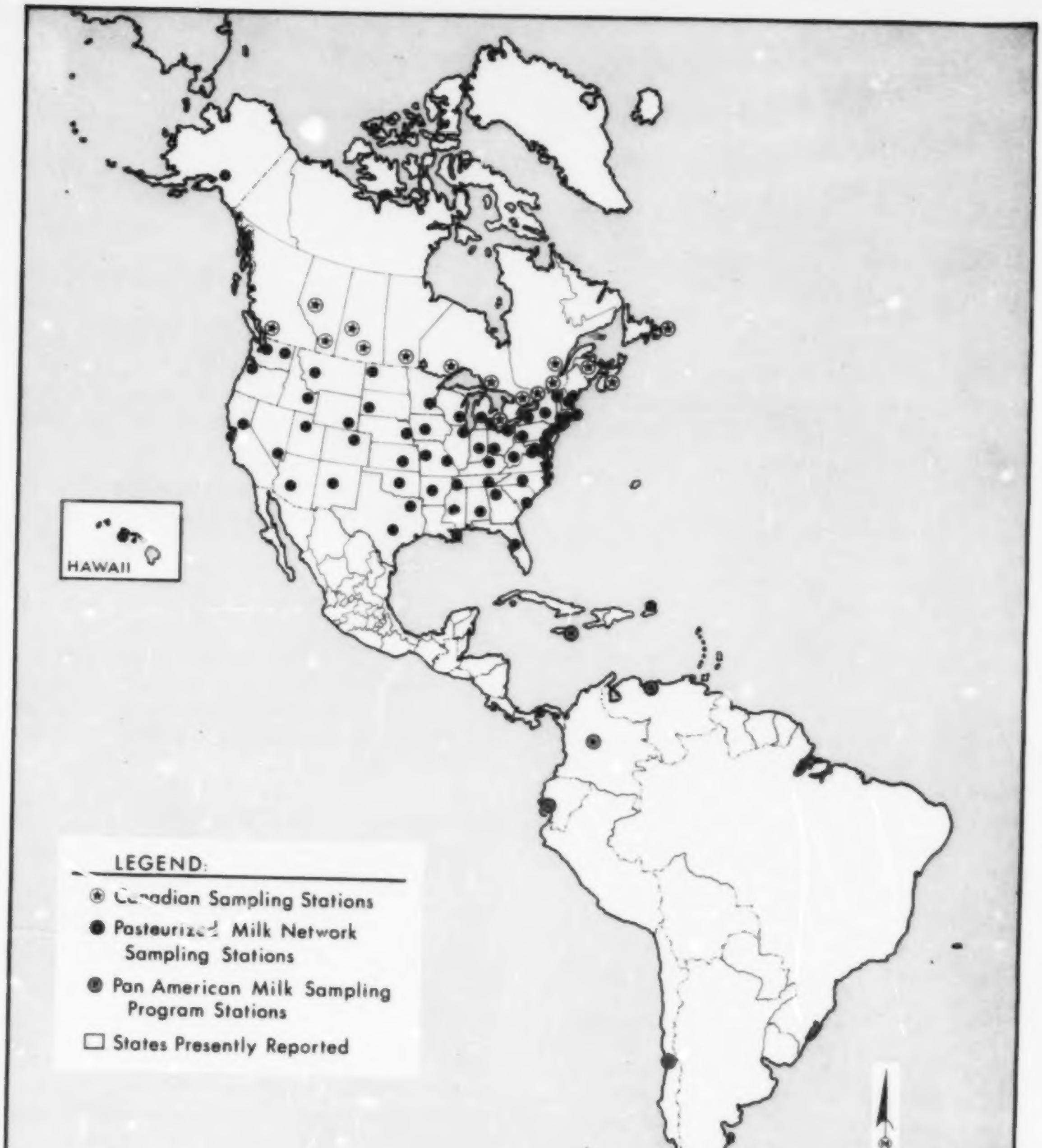
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the net-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration in milk		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

works have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	8	6	0	10
Alaska:	Palmer[c]	P	5	5	0	12
Ariz:	Phoenix[c]	P	0	0	0	0
Ark:	Little Rock[c]	P	11	12	18	12
Calif:	Sacramento[c]	P	2	1	0	0
	San Francisco[c]	P	0	3	0	0
	Del Norte	P	12	14	13	11
	Fresno	P	0	2	0	2
	Humboldt	P	3	4	0	5
	Los Angeles	P	0	2	0	1
	Mendocino	P	3	6	12	6
	Sacramento	P	0	3	0	3
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	10	3
	Shasta	P	3	3	0	5
	Sonoma	P	0	3	0	5
Colo:	Denver[c]	P	7	5	13	7
	East	R	NA		NA	
	Northeast	R	NA		NA	
	Northwest	R	NA		NA	
	South Central	R	NA		NA	
	Southeast	R	NA		NA	
	Southwest	R	NA		NA	
	West	R	NA		NA	
Conn:	Hartford[c]	P	6	7	0	9
	Central	P	8	7	9	14
Del:	Wilmington[c]	P	6	8	0	5
D.C:	Washington[c]	P	7	8	0	8
Fla:	Tampa[c]	P	7	5	54	44
	Central	R	7	7	53	41
	North	R	22	10	12	24
	Northeast	R	12	7	23	32
	Southeast	R	8	7	68	62
	Tampa Bay area	P	9	6	46	44
	West	R	NA	10	16	20
Ga:	Atlanta[c]	P	9	10	15	14
Hawaii:	Honolulu[c]	P	5	2	0	2
Idaho:	Idaho Falls[c]	P	4	5	0	6
Ill:	Chicago[c]	P	8	7	0	9
Ind:	Indianapolis[c]	P	6	7	0	5
	Central	P	8	8	10	12
	Northeast	P	9	9	15	15
	Northwest	P	10	10	15	14
	Southeast	P	8	10	15	12
	Southwest	P	10	10	10	13
Iowa:	Des Moines[c]	P	6	5	0	2
	Iowa City	P	8	7	0	14
	Des Moines	P	6 (3)	7	13	13
	Spencer	P	NS		NS	
	Little Cedar	P	9	8	11	13
Kans:	Wichita[c]	P	7	7	0	2
	Coffeyville	P	8	9	14	15
	Dodge City	P	5	7	0	6
	Falls City, Nebr	R	NS		NS	
	Hays	P	8	10	16	8
	Kansas City	P	9	9	11	14
	Topeka	P	6	9	16	11
	Wichita	P	8	11	0	11
[illegible]	Louisville[c]	P	9	9	0	4
[illegible]	New Orleans[c]	P	13	14	14	20
[illegible]ne:	Portland[c]	P	7	9	17	21
[illegible]	Baltimore[c]	P	8	8	0	6
M[illegible]s:	Boston[c]	P	5	9	0	15
[illegible]h:	Detroit[c]	P	6	7	0	11
	Grand Rapids[c]	P	7	8	0	10
	Bay City	P	NS	6	NS	17
	Charlevoix	P	8	10	17 (3)	16
	Detroit	P	6	7	14	9
	Grand Rapids	P	4	7	12	11
	Lansing	P	13	8	16 (2)	16
	Marquette	P	11	10	16 (2)	23
	Monroe	P	4	5	0 (2)	4
	South Haven	P	5	7	0 (5)	11
Minn:	Minneapolis[c]	P	9	8	0	14
	Bemidji	P	12	8	22	21
	Duluth	P	16	17	22	27
	Fergus Falls	P	8	8	11	12
	Little Falls	P	6	5	0	0
	Mankato	P	16	11	20	28
	Minneapolis	P	11	12	12	19

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—Continued						
Minn:	Rochester	P	8	7	16	22
	Worthington	P	6	6	11	12
Miss:	Jackson[c]	P	11	12	14	10
Mo:	Kansas City[c]	P	12	8	0	6
	St. Louis[c]	P	8	6	0	5
Mont:	Helena[c]	P	3	6	0	10
Nebr:	Omaha[c]	P	3	7	0	4
Nev:	Las Vegas[c]	P	4	2	0	1
N.H:	Manchester[c]	P	8	8	18	21
N.J:	Trenton[c]	P	7	8	13	10
N. Mex:	Albuquerque[c]	P	3	3	0	0
N.Y:	Buffalo[c]	P	6	7	0	11
	New York City[c]	P	7	8	0	13
	Syracuse[c]	P	7	7	0	10
	Albany	P	6 (3)	6	[d]0 (4)	[d]0
	Buffalo	P	NS		[d]0	[d]0
	Massena	P	7 (2)	7	[d]0 (2)	[d]0
	New York City	P	NS		[d]0	[d]0
	Syracuse	P	NS		[d]0	[d]0
N.C:	Charlotte[c]	P	10	11	0	12
N. Dak:	Minot[c]	P	6	9	19	11
Ohio:	Cincinnati[c]	P	7	7	0	2
	Cleveland[c]	P	6	7	12	9
Okla:	Oklahoma City[c]	P	7	6	13	9
Oreg:	Portland[c]	P	5	5	11	7
	Baker	P	NA	3	[d]0	[d]3
	Coos Bay	P	NA	5	[d]0	[d]7
	Eugene	P	NA	2	[d]0	[d]2
	Medford	P	NA	2	[d]0	[d]3
	Portland composite	P	NA	6	17	[d]6
	Portland local	P	NA	4	[d]0	[d]10
	Redmond	P	NA	3	[d]0	[d]2
	Tillamook	P	NA	5	23	[d]13
Pa:	Philadelphia[c]	P	7	8	0	9
	Pittsburgh[c]	P	9	11	0	11
	Dauphin	P	4	6	0	12
	Erie	P	8	7	0	13
	Philadelphia	P	6	8	33	17
	Pittsburgh	P	NA	10	20	17
R.I:	Providence[c]	P	7	8	0	16
S.C:	Charleston[c]	P	10	9	12	15
S. Dak:	Rapid City[c]	P	6	6	0	5
Tenn:	Chattanooga[c]	P	9	9	0	10
	Memphis[c]	P	8	7	12	9
	Chattanooga	P	NA	8	11	15
	Clinton	R	NA	9	0	14
	Fayetteville	R	NA	6	0	11
	Kingston	R	NA	7	0	14
	Knoxville	R	NA	9	0	12
	Lawrenceburg	R	NA	5	0	3
	Nashville	R	NA	7	0	12
	Pulaski	R	NA	8	0	3
Tex:	Austin[c]	P	3	1	0	0
	Dallas [c]	P	6	6	0	5
	Amarillo	R	NS	3	NS	2
	Corpus Christi	R	NS	4	NS	0
	El Paso	R	NS	3	NS	0
	Fort Worth	R	3	4	0	0
	Harlingen	R	4	3	0	0
	Houston	R	8	8	0	11
	Lubbock	R	NS	3	NS	0
	Midland	R	2	3	0	0
	San Antonio	R	NS	4	NS	0
	Texarkana	R	NS		NS	
	Tyler	R	NS	16	NS	16
	Uvalde	R	NS		NS	
	Wichita Falls	R	NS	6	NS	4
Utah:	Salt Lake City[c]	P	4	5	0	15
Vt:	Burlington[c]	P	6	6	11	14
Va:	Norfolk[c]	P	10	9	0	6
Wash:	Seattle[c]	P	6	5	14	5
	Spokane[c]	P	6	6	0	4
	Benton County	R	NS	1	NS	2
	Franklin County	R	0	4	10	7
	Sandpoint, Idaho	R	11	13	21	22
	Skagit County	R	6	8	0	12
W. Va:	Charleston[c]	P	4	7	0	8
Wisc:	Milwaukee[c]	P	6	6	0	10
Wyo:	Laramie[c]	P	2	4	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		NA	
Edmonton	P	NA		25	24
British Columbia:					
Vancouver	P	NA		30	24
Manitoba:					
Winnipeg	P	NA		28	23
New Brunswick:					
Fredericton	P	NA		18	24
Newfoundland:					
St. John's	P	NA		33	31
Nova Scotia:					
Halifax	P	NA		23	24
Ontario: Ottawa	P	NA		29	33
Sault Ste. Marie	P	NA		26	26
Thunder Bay	P	NA		14	15
Toronto	P	NA		15	13
Windsor	P	NA		15	12
Quebec: Montreal	P	NA		18	19
Quebec	P	NA		31	30
Saskatchewan:					
Regina	P	NA		14	15
Saskatoon	P	NA		20	18
CENTRAL AND SOUTH AMERICA:					
Colombia:					
Bogota	P	0	2	0	6
Chile: Santiago	P	0	0	0	2
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Kingston	P	NS	5	NS	83
Venezuela:					
Caracas	P	0	1	0	0
Canal Zone:					
Cristobal[c]	P	0	1	14	9
Puerto Rico:					
San Juan[c]	P	6	4	11	11
PMN network average[e]		6	7	5	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radio-

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nuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for October 1971 and the 12-month period, November 1970 to October 1971. Except where noted, the monthly average represents a single sample for the station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for October 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for October 1971, and the highest 12-month average was 17 pCi/liter (Duluth, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 68 pCi/liter in the United States for October 1971, and the highest 12-month average was 62 pCi/liter (Southeast Florida), representing 1.7 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

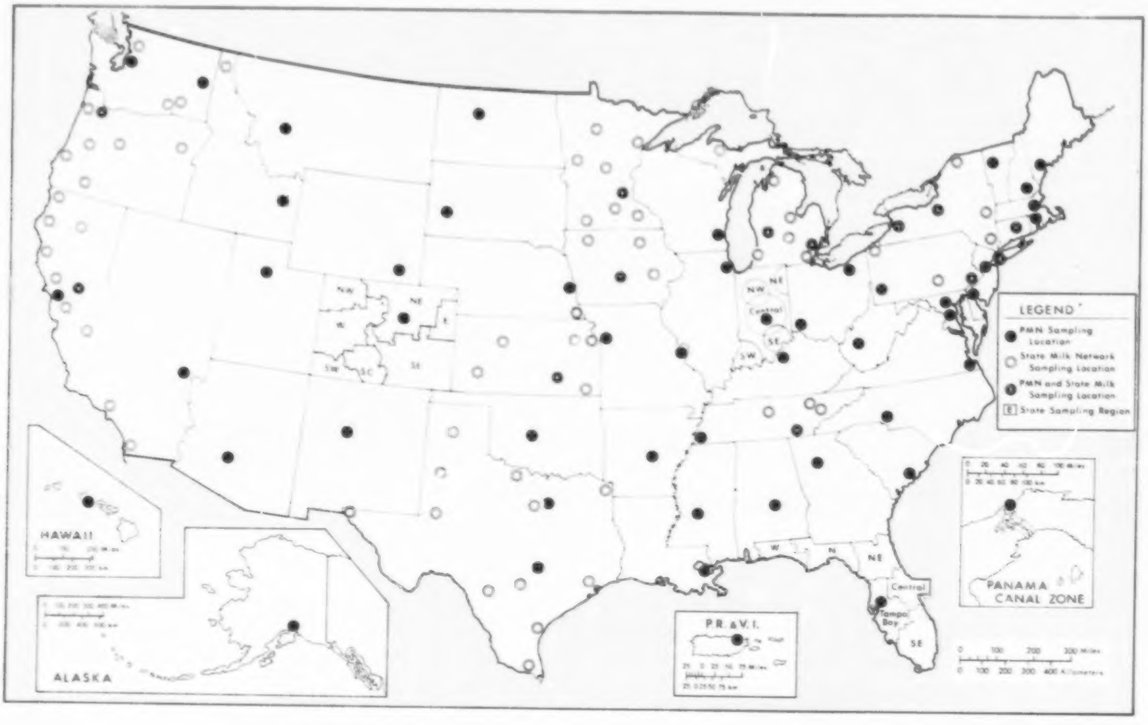

Figure 2. State and PMN milk sampling stations in the United States

Table 3. Strontium-89, iodine-131, and barium-140 in milk, October 1971 [a]

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Barium-140
Calif:	Del Norte (State)	6	
Kans:	Wichita (State)		14
N. Dak:	Minot (PMN)	11	
Chile:	Santiago (PAHO)	8	
Ecuador:	Guayaquil (PAHO)	6	

[a] No iodine-131 was detected.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	January-June 1971	December 1971
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Total Diet	April-June 1971	November 1971
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	May 1971	January 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
New York	July 1969-June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January-June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April-June 1971	November 1971
Washington	July 1968-June 1969	February 1971

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Gross Radioactivity in Surface Waters of the United States June 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Program (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 31 rivers during June 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

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(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 1. Gross radioactivity in U.S. surface waters, June 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Allegheny River:					
Pittsburgh, Pa. (7.1 miles)[b]	[c]1	<0.2	<0.2	2	6
Pittsburgh, Pa. (0.5 miles)[b]	[c]1	<.2	<.2	2	7
Beaver River:					
New Brighton, Pa	[c]1	<.2	2	3	15
Big Sandy River:					
Wayne County, W. Va	[c]1	8	<.2	35	4
Big Sioux River:					
Sioux Falls, S. Dak	[c]1	1	10	4	30
Cheyenne River:					
Edgemont, S. Dak	[d]1	17	3	102	29
Clinch River:					
Kingston, Tenn	1	<.2	<.2	2	3
Cuyahoga River:					
Cleveland, Ohio	[c]1	<.2	2	7	39

See footnotes at end of table.

Table 1. Gross radioactivity in U.S. surface waters, June 1971—continued

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Delaware River:					
Trenton, N.J	1	<.2	<.2	2	4
Detroit River:					
Detroit, Mich	[c]1	<.2	<.2	2	2
Great Lakes:					
Lake Erie, Buffalo, N.Y	[c]1	<.2	<.2	3	11
Great Miami River:					
Eldean, Ohio	[d]1	<.2	3	4	14
Sellars Road, Ohio	[d]1	1	2	6	13
Fairfield, Ohio	[d]1	<.2	4	4	12
American Materials Bridge, Ohio	[d]1	1	1	8	17
Lost Bridge, Ohio	[d]1	2	3	13	29
Green River:					
Pottsville, Ky	[c]1	1	<.2	4	6
Guyandotte River:					
Guyandotte, W. Va	[c]1	3	<.2	9	5
Kanawha River:					
Winfield Dam, W. Va	[c]1	2	2	4	4
Mason County, W. Va	[c]1	1	<.2	3	3
Kentucky River:					
Lock and Dam No. 1, Ky	[d]1	3	1	14	7
Licking River:					
Covington, Ky	[d]1	1	<.2	4	8
Little Miami River:					
Cincinnati, Ohio	[d]1	3	1	14	15
Maumee River:					
Toledo, Ohio	[c]1	2	2	6	13
Mississippi River:					
Burlington, Iowa	[d]1	<.2	<.2	11	6
Missouri River:					
Yankton, S. Dak	[c]1	<.2	4	2	20
Omaha, Nebr	[c]1	4	5	22	30
St. Joseph, Mo	[c]1	2	7	30	16
St. Louis, Mo	[c]1	6	4	26	21
Monongahela River:					
Pittsburgh, Pa. (4.5 miles)[b]	[c]1	<.2	1	3	6
Pittsburgh, Pa. (0.8 miles)[b]	[c]1	1	<.2	2	8
Muskingum River:					
Lock and Dam No. 2, Ohio	[c]1	<.2	2	3	7
North Platte River:					
Henry, Nebr	[c]1	1	12	2	30
Ohio River:					
South Height, Pa	[c]1	<.2	<.2	2	7
Hancock, W. Va	[c]1	<.2	<.2	1	7
Warwood, W. Va	[c]1	<.2	1	2	8
Ironton, Ohio	[d]1	3	<.2	20	8
Greenup Dam, Ky	[d]1	3	<.2	11	8
Portsmouth Ohio	[d]1	2	1	16	9
Cane Run, Ky	[c]1	2	<.2	8	6
Maysville, Ky	[d]1	2	<.2	6	7
Cincinnati, Ohio	6	<.3 (<.2—1)	<.2 (<.2—<.2)	4 (2—6)	6.3 (5—8)
Miami Fort, Ohio	[d]1	1	1	7	9
Anderson Ferry, Ohio	[d]1	1	1	7	7
Markland Dam, Ky	[d]1	1	<.2	5	9
Madison, Ind	[d]1	1	<.2	2	6
Louisville, Ky	[c]1	1	<.2	8	6
Meldahl Dam, Ohio	[d]1	<.2	<.2	<1	8
Boyd County, Ky	[c]1	1	1	3	6
Gallipolis, Ohio	[c]1	<.2	2	2	8
Kyger Creek, W. Va	[c]1	<.2	3	2	8
Addison, Ohio	[c]1	1	2	2	6
Old Lock No. 19, W. Va	[c]1	1	<.2	15	9
Evansville, Ind	[c]1	2	1	9	6
Marietta, Ohio	[c]1	1	<.2	3	2
New Martinsville, W. Va	[c]1	<.2	<.2	3	7
Platte River:					
Plattsmouth, Nebr	[c]1	2	2	31	17
Roanoke River:					
John Kerr Dam, Va	4	<.2 (<.2—<.2)	<.2 (<.2—<.2)	3 (<1—5)	4.5 (2—6)
St. Lawrence River:					
Massena, N.Y	3	<.2 (<.2—<.2)	<.7 (<.2—1)	1.7 (1—2)	6 (3—8)
St. Mary's River:					
Sault Ste. Marie, Mich	[c]1	<.2	<.2	1	3
Susquehanna River:					
Conowingo Dam, Md	[c]1	1	3	2	6
Wabash River:					
New Harmony, Ind	[c]1	1	2	7	12
Whitewater River:					
Suspension Bridge, Ohio	[d]1	1	1	10	13

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[a] Where more than one sample is analyzed during the month, the minimum and maximum values are in parentheses.
[b] Distance from mouth of river.
[c] Indicates a composited sample for the third quarter ending in June 1971 of 1971 Water Year (Oct 1970–Sept 1971).
[d] Indicates single monthly grab samples.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California Air Sampling Program, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Plutonium in Airborne Particulates	January-March 1971	November 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January-December 1968	April 1971
Mexican Air Monitoring Program	August-December 1970 and January 1971	October 1971

1. Radiation Alert Network
October 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1971.

All field estimates reported were within normal limits for the reporting station.

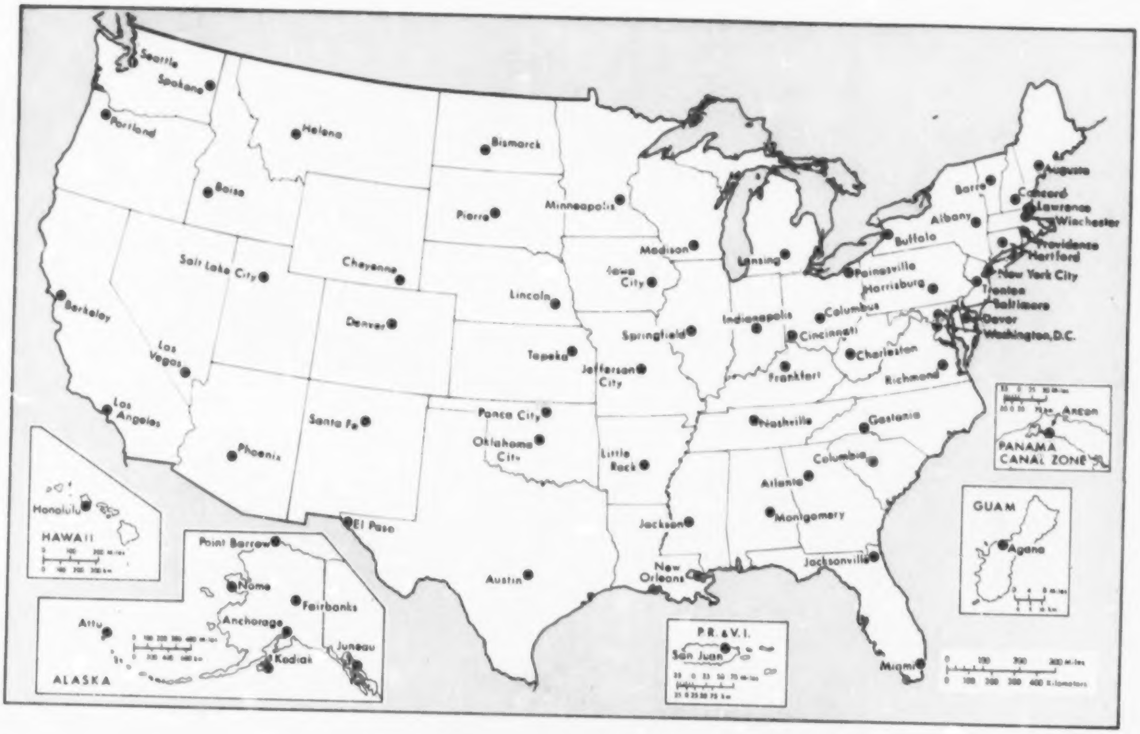
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Iowa City
Lincoln
Denver
Berkeley
Las Vegas
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Little Rock
Columbia
Phoenix
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
GUAM
Agana
Ancon
PANAMA CANAL ZONE

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	5	1	2	2	28	2	28	9
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	14	1	0	0	7	30	7	30	11
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	9	11	1	4	0				
Ark:	Little Rock	8	1	0	0	0				
Calif:	Berkeley	19	1	0	0	0				
	Los Angeles	0				0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	18	7	0	3	1	4	(b)		
Conn:	Hartford	18	3	0	1	2	28	2	28	0
Del:	Dover	16	1	0	0	0				
D.C:	Washington	21	2	0	0	0				
Fla:	Jacksonville	18	1	0	0	4	97	4	97	25
	Miami	17	0	0	0	8	134	8	134	0
Ga:	Atlanta	10	2	1	2	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	19	1	0	0	3	18	(b)		
Idaho:	Boise	19	6	1	2	3	22	3	22	0
Ill:	Springfield	14	5	0	2	0				
Ind:	Indianapolis	19	2	0	0	0				
Iowa:	Iowa City	20	4	0	2	2	27	2	27	0
Kans:	Topeka	20	4	1	2	7	62	7	62	2
Ky:	Frankfort	0				0				
La:	New Orleans	21	1	0	0	4	63	(b)		
Maine:	Augusta	15	2	0	1	2	81	2	81	0
Md:	Baltimore	19	2	0	0	3	30	3	30	0
Mass:	Lawrence	19	3	0	1	3	62	2	44	0
	Winchester	18	4	0	1	3	63	3	63	0
Mich:	Lansing	20	1	0	1	7	63	7	63	10
Minn:	Minneapolis	16	3	0	1	6	137	6	137	28
Miss:	Jackson	15	4	0	1	1	5	1	5	2
Mo:	Jefferson City	19	4	0	1	6	65	6	65	0
Mont:	Helena	17	3	0	1	3	16	2	11	0
Nebr:	Lincoln	9	8	2	4	1	30	1	30	13
Nev:	Las Vegas	18	3	1	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	4	97	4	97	0
N. Mex:	Santa Fe	12	3	0	1	0				
N.Y:	Albany	17	1	0	0	0				
	Buffalo	15	2	0	1	0				
	New York City	0				0				
N.C:	Gastonia	15	10	1	3	1	8	(b)		
N. Dak:	Bismarck	18	3	0	1	1	52	1	52	0
Ohio:	Cincinnati	0				0				
	Columbus	3	2	1	1	0				
	Painesville	18	3	0	1	5	31	5	31	15
Okla:	Oklahoma City	0				0				
	Ponca City	18	5	0	2	6	75	5	50	3
Oreg:	Portland	20	1	0	0	9	72	9	72	3
Pa:	Harrisburg	12	2	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	19	5	0	1	1	16	1	16	0
S.C:	Columbia	18	4	0	1	4	91	4	91	0
S. Dak:	Pierre	19	6	1	3	0				
Tenn:	Nashville	19	3	0	1	3	42	3	42	3
Tex:	Austin	5	2	0	1	1	11	(b)		
	El Paso	18	5	0	1	0				
Utah:	Salt Lake City	27	2	0	1	9	80	7	64	6
Vt:	Barre	19	7	0	2	4	56	4	56	4
Va:	Richmond	19	2	0	0	5	144	4	123	29
Wash:	Seattle	8	0	0	0	6	75	(b)		
	Spokane	17	2	0	1	0				
W. Va:	Charleston	18	3	0	1	3	29	3	29	5
Wisc:	Madison	20	2	0	1	5	25	5	25	1
Wyo:	Cheyenne	19	7	0	3	1	8	1	8	1
Network summary		961	11	0	1	146	62	4	54	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] October 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for October 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	7	0.1	0.1	0.1	74	1.9
Coral Harbour	7	.0	.0	.0	(a)	.3
Edmonton	7	.1	.0	.0	50	3.4
Ft. Churchill	7	.0	.0	.0	20	.9
Fredericton	7	.1	.0	.1	14	1.2
Goose Bay	7	.0	.0	.0	53	1.6
Halifax	6	.1	.1	.1	15	1.0
Inuvik	7	.0	.0	.0	15	1.2
Montreal	4	.1	.0	.1	44	1.7
Moosonee	7	.1	.1	.1	12	1.6
Ottawa	6	.1	.0	.0	50	2.2
Quebec	7	.0	.0	.0	35	2.6
Regina	6	.1	.0	.1	32	1.3
Resolute	7	.1	.0	.0	49	.5
St. John's, Nfld	6	.1	.1	.1	13	.6
Saskatoon	7	.1	.0	.1	35	.4
Sault Ste. Marie	7	.1	.0	.1	47	2.8
Thunder Bay	7	.1	.0	.1	25	3.5
Toronto	3	.2	.0	.1	29	1.5
Vancouver	7	.0	.0	.0	9	1.2
Whitehorse	7	.0	.0	.0	12	.3
Windsor	7	.1	.0	.1	17	.5
Winnipeg	7	.1	.0	.0	29	2.4
Yellowknife	6	.1	.0	.1	20	.7
Network summary	156	0.2	0.0	0.1	30	1.5

[a] Less than 0.1 inches precipitation.

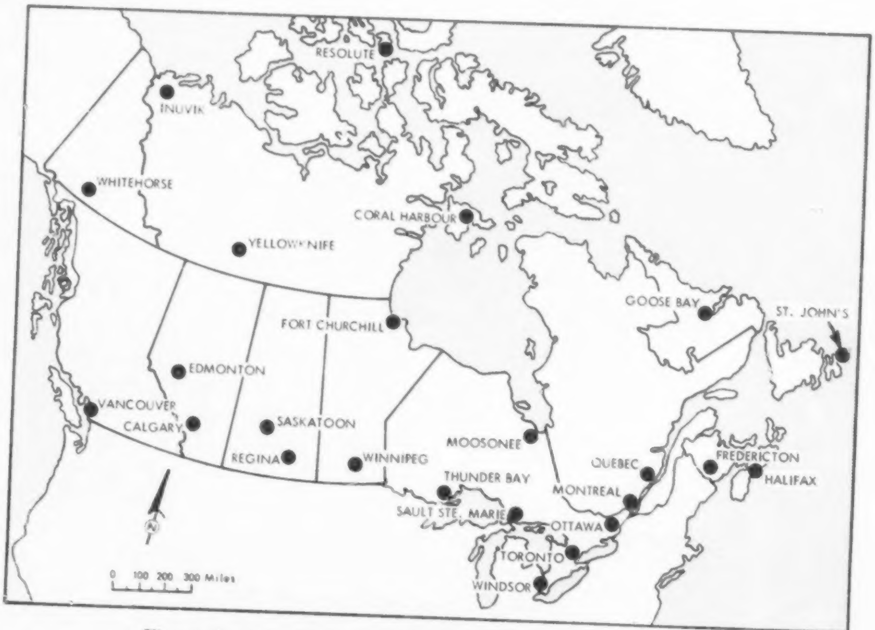
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Air Sampling Program October 1971

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The October 1971 air monitoring results from the participating countries are given in table 3.

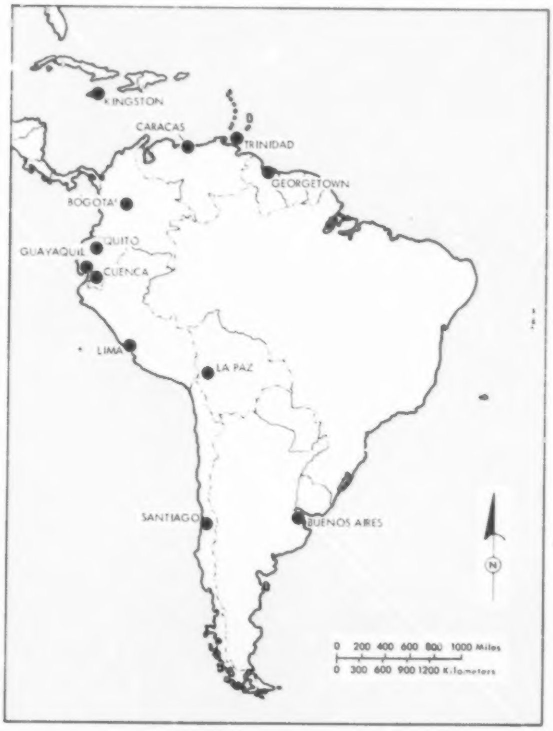

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, October 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	5	0.88	0.04	0.46
Chile:	Santiago	31	.90	.07	.41
Colombia:	Bogota	20	.09	.00	.03
Ecuador:	Cuenca	5	.11	.03	.08
	Guayaquil	14	1.30	.27	.74
	Quito	12	.23	.00	.04
Guyana:	Georgetown	13	.24	.00	.08
Jamaica:	Kingston	0			
Peru:	Lima	19	1.17	.17	.56
Venezuela:	Caracas	19	.54	.00	.06
West Indies:	Trinidad	15	.39	.01	.15
Pan American summary		153	1.30	0.00	0.27

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program October 1971

Bureau of Radiological Health California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations, operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

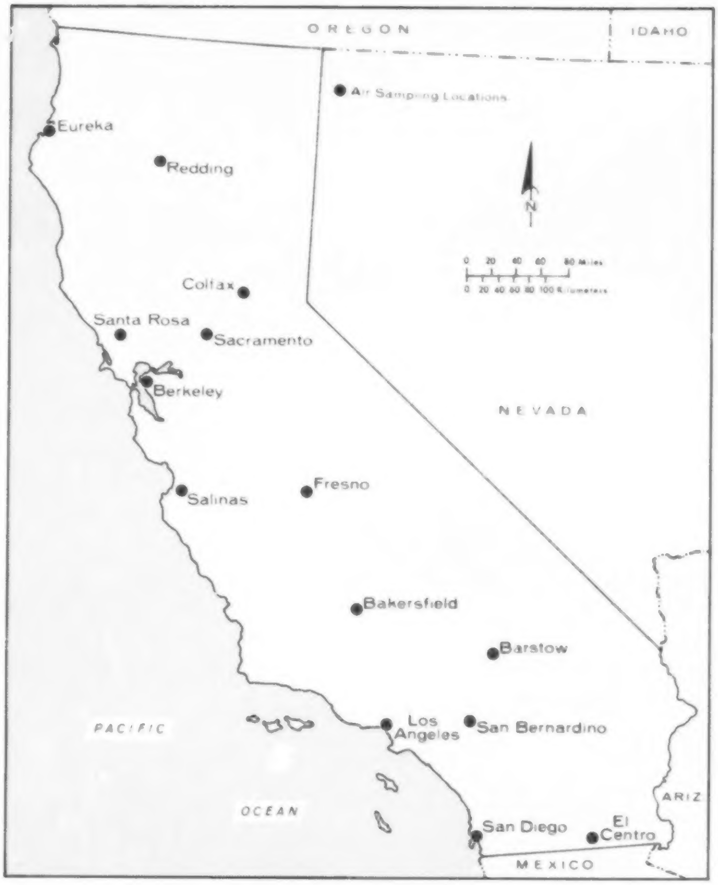
OREGON
IDAHO
Air Sampling Locations
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic-feet-per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma-scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for October 1971.

Table 4. Gross beta radioactivity in California air, October 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	28	1.23	0.10	0.34
Barstow	31	1.08	.12	.39
Berkeley	31	.29	.04	.14
Colfax	31	.34	.07	.18
El Centro	29	2.63	.18	.63
Eureka	29	.26	.04	.10
Fresno	29	1.45	.05	.37
Los Angeles	30	.58	.11	.25
Redding	31	.39	.10	.15
Sacramento	29	.91	.06	.26
Salinas	29	2.05	.10	.36
San Bernardino	29	.73	.11	.23
San Diego	29	.54	.11	.22
Santa Rosa	31	1.59	.05	.30
Summary	416	2.63	0.04	0.28

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Air Surveillance Network, July 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network, operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

Sampling

Twenty-four hour samples of airborne particulates are collected daily at each active station on 4-inch diameter, glass-fiber filters at a flow rate of about 350 m^3 of air per day. Samples may be collected for shorter periods to document specific radioactivity releases. Activated charcoal cartridges following the filters are used regularly for collection of radioiodines at 22 stations near the NTS, and charcoal cartridges can be added to all other stations by telephone request. Continuous gamma radioactivity rate recorders are also located at 32 stations. The stations are operated by State health department personnel and by private individuals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS.

Analysis

The particulate filters are counted 5 minutes for gross beta radioactivity as soon as they are received and at 5 and 12 days after collection. Samples are counted on gas-flow proportional counters calibrated over a range of beta energies from 0.1 to 1.8 MeV. A conservative efficiency value of 45 percent (corresponding to an average maximum beta energy of 0.5 MeV) is used for data conversion. Those filters with total gross beta radioactivities of 500 cpm or greater are gamma scanned on a 4- by 4-inch sodium iodide (thallium-activated) crystal connected to a 400-channel gamma spectrometer. Individual radionuclides are quantitated from spectrometer data by the use of a computer and a matrix technique. The 5- and 12-day beta counts are used to extrapolate gross beta concentrations to mid-collection time for reporting. Extrapolation is accomplished by computer programs and is routinely based on a $T^{-1.2}$ decay. For known releases of radioactivity the decay rate is determined experimentally and is used in the extrapolations.

All charcoal cartridges are counted 10 minutes with a gamma spectrometer. Data from

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[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

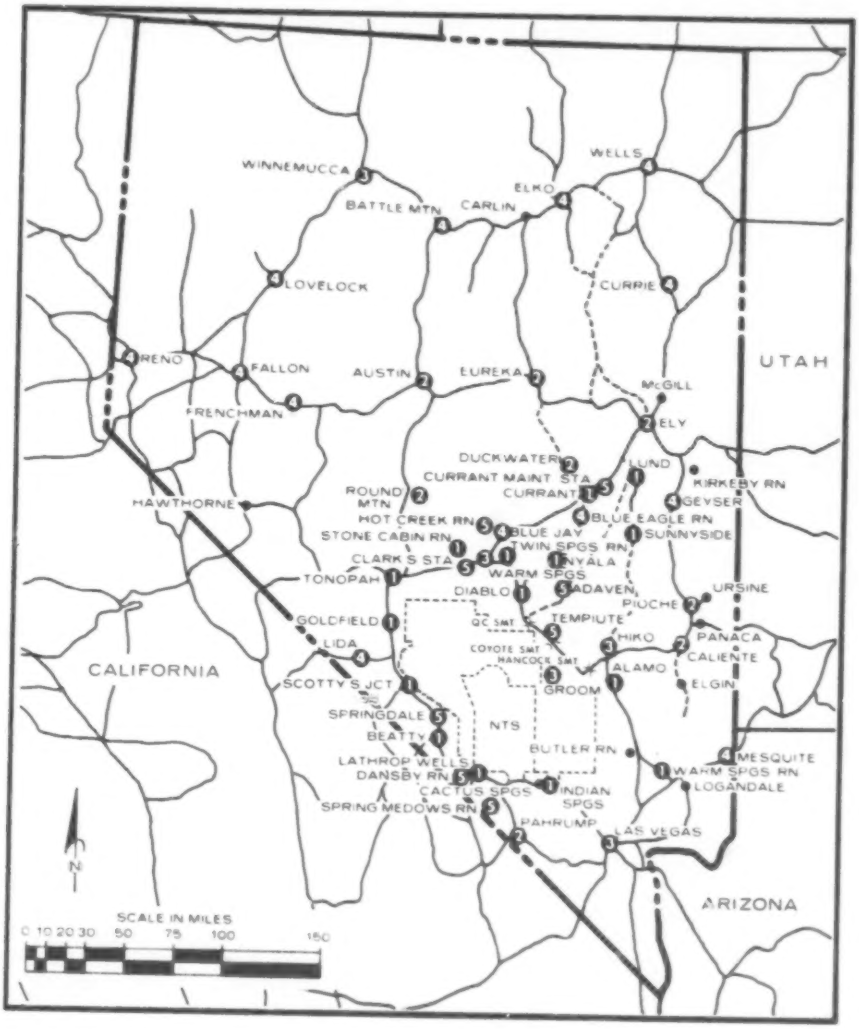
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
UTAH
McGILL
FRENCHMAN
ELY
DUCKWATER
CURRANT MAINT STA
LUND
CURRANT
KIRKEBY RN
ROUND MTN
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
STONE CABIN RN
BLUE JAY
SUNNYSIDE
TWIN SPGS RN
CLARK'S STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
URSINE
PIOCHE
GOLDFIELD
QC SMT
TEMPIUTE
HIKO
PANACA
COYOTE SMT
HANCOCK SMT
CALIENTE
LIDA
ALAMO
CALIFORNIA
SCOTTY'S JCT
GROOM
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
LATHROP WELLS
MESQUITE
DANSBY RN
WARM SPGS RN
CACTUS SPGS
INDIAN SPGS
LOGANDALE
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
N
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. WERL Air Surveillance Network stations in Nevada

those cartridges having a net gross gamma count rate greater than 300 cpm are analyzed by a computer matrix to quantitate individual radionuclides.

Results

Table 1 presents the monthly average gross beta radiation in air particulates during July 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06-0.07 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3.

From gamma spectrometry results, zirconium-niobium-95, ruthenium-106, and cerium-144 from worldwide fallout were identified in varying combinations on filters collected in all States within the network except for Missouri, Arkansas, Oklahoma, Texas, and New Mexico. None of the standby stations were operated in

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Table 1. Summary of gross beta radioactivity concentrations in air, July 1971

Station location		Number of samples	Concentrations[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	2.1	0.2	0.5
	Phoenix	31	.8	<.1	.4
	Seligman	30	1.2	.2	.5
	Winslow	30	.6	.2	.4
Ark:	Little Rock	11	.9	<.1	.4
Calif:	Baker	30	1.7	.3	.7
	Barstow	31	1.5	.3	.7
	Bishop	31	1.8	.2	.7
	Death Valley Junction	26	1.7	<.1	.6
	Furnace Creek	29	1.9	<.1	.8
	Indio	29	1.3	.2	.5
	Lone Pine	30	1.6	<.1	.6
	Needles	26	1.8	.2	.6
	Ridgecrest	31	1.3	.2	.5
	Shoshone	31	1.4	.2	.5
Colo:	Denver	21	.9	.2	.5
	Durango	31	.8	.2	.4
Idaho:	Boise	31	1.6	.3	.8
	Idaho Falls	21	1.5	.3	.9
	Preston	31	1.8	.4	.9
	Twin Falls	31	1.3	.4	.8
Iowa:	Iowa City	20	1.3	<.1	.7
	Sioux City	27	1.1	.3	.7
Kans:	Dodge City	31	.5	.2	.3
La:	Lake Charles	20	.5	.1	.3
	Monroe	20	.9	<.1	.3
	New Orleans	17	.5	.1	.3
Minn:	Minneapolis	20	1.0	.2	.7
Mo:	Joplin	31	1.3	<.1	.6
	St. Joseph	31	1.2	.2	.6
	St. Louis	31	1.4	<.1	.6
Nebr:	North Platte	26	1.6	<.1	.7
Nev:	Alamo	31	1.5	.2	.6
	Austin	28	1.7	.2	.7
	Battle Mountain	31	1.6	.2	.8
	Beatty	31	1.8	.2	.7
	Blue Eagle Ranch (Currant)	30	1.5	<.1	.6
	Blue Jay	31	1.6	<.1	.6
	Caliente	31	1.6	<.1	.6
	Currant Ranch	31	1.3	<.1	.4
	Currie	31	1.7	.2	.7
	Diablo	31	1.8	.3	.7
	Duckwater	25	1.4	.1	.6
	Elko	31	1.4	.2	.6
	Ely	27	1.4	.2	.6
	Eureka	31	1.8	<.1	.7
	Fallini's Twin Springs Ranch	31	1.5	.2	.7
	Fallon	31	1.7	.1	.7
	Frenchman Station	31	2.0	<.1	.8
	Garrison	31	1.5	<.1	.7
	Geyser Maintenance Station	20	1.6	.2	.6
	Goldfield	30	1.5	.2	.6
	Groom Lake	25	1.4	.2	.6
	Hiko	31	1.5	.2	.6
	Indian Springs	31	1.5	.2	.6
	Las Vegas	21	1.4	<.1	.5
	Lathrop Wells	31	1.9	.3	.7
	Lida	30	1.5	<.1	.5
	Lovelock	31	1.8	.3	.8
	Lund	31	1.4	.2	.6
	Mesquite	31	1.7	.3	.6
	Nyala	32	1.6	.2	.7
	Pahrump	25	1.6	.2	.6
	Pioche	29	1.3	.1	.5
	Reno	31	1.8	.2	.7
	Round Mountain	30	1.6	<.1	.6
	Scotty's Junction	31	2.0	.2	.7
	Stone Cabin Ranch	32	1.4	<.1	.6
	Sunnyside	27	1.3	<.1	.5
	Tonopah	31	1.7	.2	.7
	Tonopah Test Range	28	1.8	<.1	.6
	Warm Springs Ranch	31	1.4	.2	.6
	Wells	31	1.9	.2	.8
	Winnemucca	31	1.4	.2	.7
N. Mex:	Albuquerque	25	.5	.1	.3
	Carlsbad	31	.6	.2	.3
Okla:	Muskogee	31	1.1	<.1	.5
Oreg:	Burns	31	1.7	.4	.8
	Medford	23	1.5	.2	.7
S. Dak:	Aberdeen	31	1.2	.3	.7
	Rapid City	31	1.7	.3	.9
Tex:	Abilene	28	.9	<.1	.4
	Amarillo	31	1.0	<.1	.5
	Austin	12	.5	<.1	.3
	Fort Worth	31	1.2	<.1	.4

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See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, July 1971 continued

Station location		Number of samples	Concentrations[a] (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Bryce Canyon	21	1.4	<0.1	0.4
	Cedar City	27	1.3	.2	.5
	Delta	29	1.0	.2	.5
	Dugway	30	1.3	.2	.6
	Enterprise	31	1.4	.2	.5
	Logan	31	1.3	.2	.7
	Milford	29	1.8	<.1	.5
	Monticello	19	1.6	<.1	.3
	Parowan	31	1.7	<.1	.5
	Provo	23	1.2	.2	.6
	Roosevelt	31	1.5	.2	.6
	St. George	31	1.1	.2	.5
	Salt Lake City	30	1.5	.2	.8
	Wendover	31	1.6	.2	.8
Wash:	Seattle	21	1.6	.1	.4
	Spokane	17	1.3	.3	.8
Wyo:	Rock Springs	30	1.5	<.1	.8
	Worland	31	2.0	<.1	1.0

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

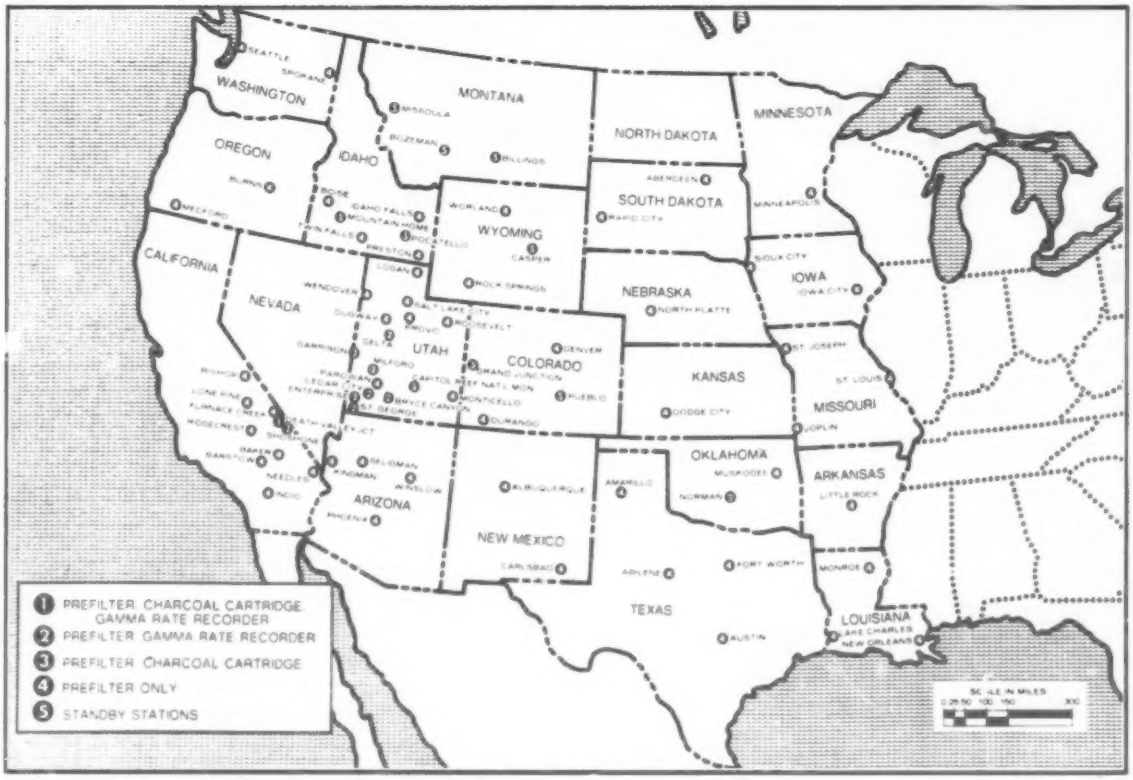
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
LOGAN
WYOMING
WORLAND
CASPER
ROCK SPRINGS
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNEAPOLIS
CALIFORNIA
NEVADA
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
GARRISON
UTAH
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST. GEORGE
CAPITOL REEF NAT'L MON
BRYCE CANYON
MONTICELLO
GRAND JUNCTION
COLORADO
DENVER
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
ST. JOSEPH
ST. LOUIS
MISSOURI
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
DEATH VALLEY JCT
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
KINGMAN
SELIGMAN
WINSLOW
ARIZONA
PHOENIX
ALBUQUERQUE
NEW MEXICO
CARLSBAD
AMARILLO
OKLAHOMA
MUSKOGEE
NORMAN
ARKANSAS
LITTLE ROCK
ABILENE
FORT WORTH
TEXAS
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
SCALE IN MILES
0 25 50 100 150 300
① PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. WERL Air Surveillance Network stations outside Nevada

Montana. The highest concentrations of these radionuclides, respectively, were 1.0 pCi/m^3 (Shoshone and Scotty's Junction), 1.8 pCi/m^3 (Furnace Creek and Lathrop Wells), and 1.6 pCi/m^3 (Shoshone). No radioactivity was identified on any of the charcoal cartridges.

Complete summaries of the daily station results are distributed to EPA regional offices and state health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

Surface Air Sampling Program—80th Meridian Network [1] January-December 1969

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objective of this program is to study the spatial and temporal distribution of nuclear weapons debris and lead in the surface air.

The basic network consists of a line of sites approximately along the 80th Meridian extending from about 76° N to 90° S latitudes (figure 1). Since 1963, a number of sites has been added to investigate the possible effects of longitude, elevation, and proximity to coastlines; and from late 1965 through March 1969, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2,200 cubic meters of air per day are filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air.

The filters are returned to HASL at the end of each month and under normal conditions, composited into monthly samples for analysis. Until late 1969, the composited sample was first gamma counted and then sent to a contractor laboratory for radiochemical analysis. In the current program, each sample is split into equal aliquots, one for gamma counting and spectrometry and the other for radiochemistry. Hence, half of each sample is now being kept and stored for possible future work.

Daily pump pressure drop and temperature readings are also submitted to HASL along with the samples for the purpose of computing the volume of sampled air.

Gamma analysis

The gamma activity of half of the monthly composites are obtained with a 8- by 4-inch sodium iodide (Tl) crystal as soon as possible after receipt of the samples. The integrated response between 100 KeV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout; and the total gamma activities are reported in units of photons per minute per 1,000 standard cubic meters.

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[1] Summarized from "Fallout Program Quarterly Summary Report," HASL-239 (January 1, 1971); HASL-245 (October 1, 1971) available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

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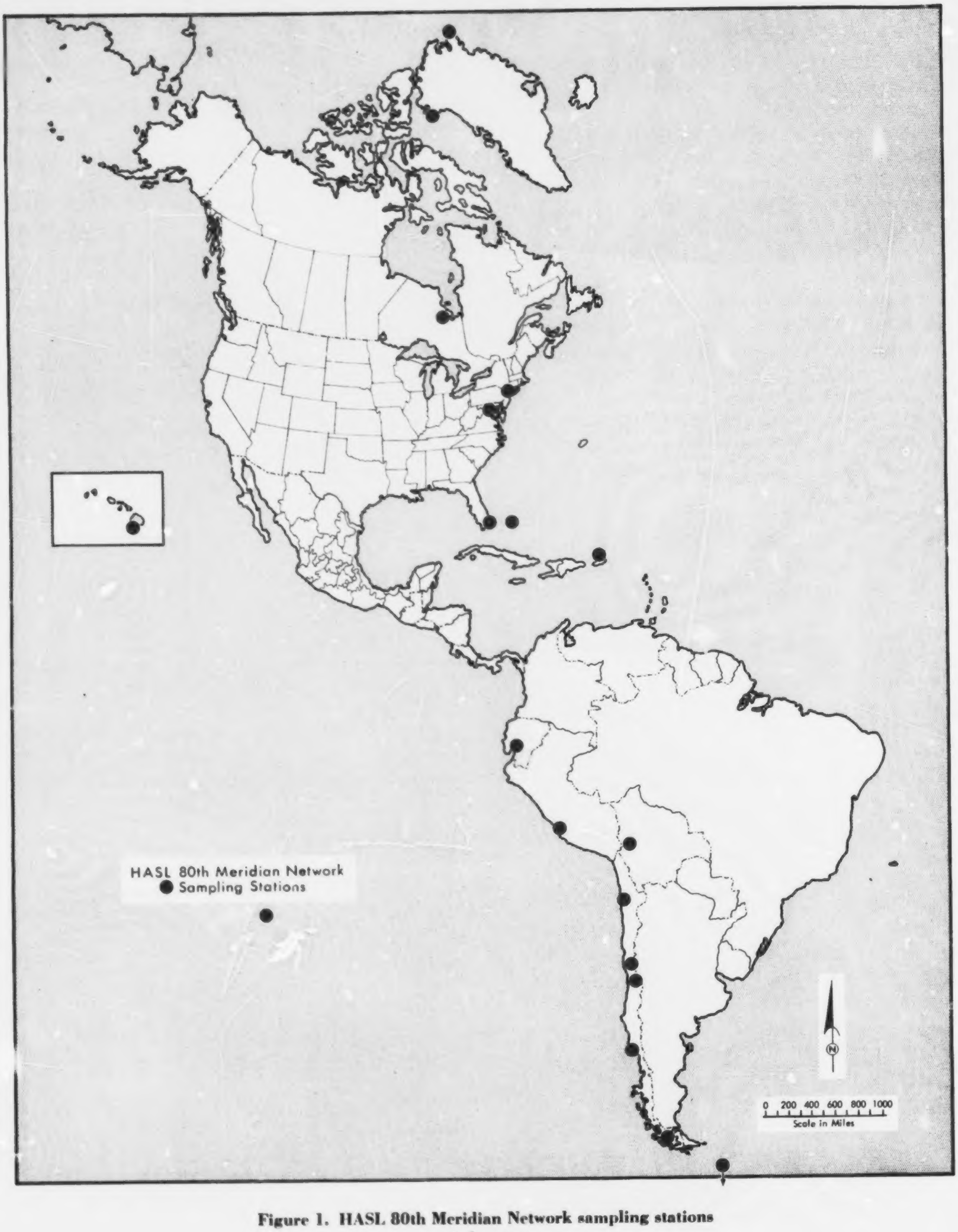

HASL 80th Meridian Network
● Sampling Stations
N
0 200 400 600 800 1000
Scale in Miles

Figure 1. HASL 80th Meridian Network sampling stations

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Radiochemical analyses

The other halves of the monthly composites are sent to a contractor laboratory for radiochemical analyses.

There were no major weapon test series from the end of 1962 until May 1966. Consequently, only the longer-lived artificially produced radionuclides were present in the filters collected during this period and emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, plutonium-238, and plutonium-239. In samples collected after French or Chinese atmospheric weapons tests, additional short-lived nuclides were analyzed such as strontium-89, zirconium-95, and cerium-141.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air of all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer nuclides can be associated with debris from a single detonation or series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U. S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 were disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP-9A power source.

As the levels of any of the radionuclides drop to below practical detection limits they are eliminated from the radiochemical program; thus cadmium-109 was not analyzed after the end of 1967.

Most of the analyses of surface air samples were carried out from July 1967 through June 1969 by the Tracerlab Inc., Richmond, Calif., and from July 1969 through June 1970 by the Trapelo Division West, Richmond, Calif.

Table 1. Station location

Site		Latitude	Longitude (west)	Elevation (meters)
Greenland:	Thule	76° 36′N	68° 35′	259
Ontario:	Moosonee	51° 16′N	80° 30′	10
N.Y:	New York	40° 48′N	73° 58′	38
Va:	Sterling	38° 58′N	77° 25′	76
Fla:	Miami	25° 49′N	80° 17′	4
Bahamas:	Bimini	25° 46′N	79° 22′	3
Hawaii:	Mauna Loa	19° 28′N	155° 36′	3,401
P.R:	San Juan	18° 26′N	66° 00′	10
Panama:	Balboa	8° 58′N	79° 34′	23
Ecuador:	Guayaquil	2° 10′S	79° 52′	7
Peru:	Lima	12° 01′S	77° 08′	13
Boliva:	Chacaltaya	16° 21′S	68° 07′	5,220
Chile:	Antofagasta	23° 37′S	70° 16′	31
	Isle de Pasqua	27° 10′S	109° 26′	41
	Portillo	32° 50′S	70° 08′	2,850
	Santiago	33° 27′S	70° 42′	520
	Puerto Montt	41° 27′S	72° 57′	7
	Punta Arenas	53° 08′S	70° 53′	35
	Gabriel Gonzales Videla	64° 49′S	62° 52′	10

Results

The radioactivity concentrations in surface air during January-December 1969 are presented in tables 2 through 8. The sites are listed

Table 2. Strontium-89 concentrations in air, 1969 [a]

Site		Concentration[b] (dpm/1,000 standard m^3 at midmonth)			
		Sept	Oct	Nov	Dec
Greenland:	Thule	9.20	8.70	—	—
Ontario:	Moosonee	16.7	8.66	4.57	2.50
N.Y:	New York City	12.6	10.6	4.61	3.57
Va:	Sterling	19.7	10.6	5.45	3.40
Fla:	Miami	4.95	8.37	7.68	7.96
Bahamas:	Bimini	8.81	11.2	9.90	15.2
Hawaii:	Mauna Loa	13.0	21.5	12.0	8.47
P.R:	San Juan	5.92	5.19	4.72	6.67
Panama:	Balboa	[c].39	[c]1.68	1.48	3.38
Ecuador:	Guayaquil	1.29	[c]1.71	2.68	[c]1.05
Peru:	Lima	[c]2.87	10.9	[c]4.12	[c]1.94
Bolivia:	Chacaltaya	5.16	[c]3.92	[c].85	1.71
Chile:	Antofagasta	—	[c]2.67	(d)	[c]5.80
	Santiago	5.09	9.33	[c]4.84	(d)
	Puerto Montt	[c]1.54	[c]1.86	111	—
	Punta Arenas	[c]1.49	[c]1.05	[c].62	(d)

[a] No data reported for January-August 1969.
[b] Errors are less than 20 percent except:
[c] Error between 20-100 percent.
[d] Error greater than 100 percent.
—, no data reported.

Table 3. Strontium-90 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	3.96	3.85	5.31	5.16	2.41	1.32	3.34	7.23	2.45	3.74	—	—
Ocean station:	Bravo	1.72	2.94	2.59	—	—	—	—	—	—	—	—	—
	Charlie	1.77	—	2.25	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	2.70	3.40	5.57	7.73	4.98	4.90	6.31	8.21	4.46	2.54	1.73	1.31
Ocean station:	Delta	2.02	2.50	12.02	—	—	—	—	—	—	—	—	—
N.Y:	New York City	2.62	2.85	3.43	5.22	5.36	6.37	—	.64	3.74	3.50	1.70	2.13
Va:	Sterling	3.23	—	4.80	5.43	9.39	8.66	7.58	7.63	5.16	3.11	2.00	1.80
Ocean station:	Echo	2.72	3.42	3.79	—	—	—	—	—	—	—	—	—
Fla:	Miami	4.63	—	5.03	4.51	1.91	2.51	4.53	4.04	1.38	2.69	2.93	3.42
Bahamas:	Bimini	3.13	3.38	3.75	6.59	5.30	2.02	5.40	5.17	2.36	2.17	3.62	5.95
Hawaii:	Mauna Loa	4.58	3.59	5.50	9.13	11.58	9.81	8.72	4.95	3.63	4.36	2.29	2.18
P.R:	San Juan	1.98	4.25	4.73	4.40	3.97	3.81	5.44	4.79	1.86	1.51	2.20	2.96
Panama:	Balboa	1.24	2.56	2.41	2.82	1.41	.46	1.43	.41	.19	[b] .36	.45	1.25
Ecuador:	Guayaquil	1.73	1.29	.37	.26	.39	.49	.94	.32	.98	1.80	1.84	1.92
Peru:	Lima	4.75	5.20	2.79	2.16	.51	1.22	3.52	3.92	5.79	12.19	7.82	5.07
Bolivia:	Chacaltaya	1.31	1.47	.93	.96	2.33	3.21	6.41	5.31	3.11	3.51	[b] .25	1.54
Chile:	Antofagasta	3.98	4.23	2.84	2.34	2.30	—	4.64	—	—	4.09	5.68	17.1
	Portillo	24.4	22.9	—	—	—	—	—	—	—	—	—	—
	Santiago	4.93	5.38	5.32	3.41	3.59	4.54	5.06	1.91	7.84	7.24	5.44	6.68
	Puerto Montt	4.12	2.95	4.13	3.02	2.47	2.16	2.61	2.87	2.63	2.99	2.33	—
	Punta Arenas	1.62	1.90	2.65	1.26	1.37	1.10	1.85	1.09	1.40	.97	1.10	1.20

[a] Errors are less than 20 percent except:
[b] error between 20 percent and 100 percent.
—, no data reported.

Table 4. Zirconium-95 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	5.86	10.8	17.7	—	22.8	17.5	49.5		29.1	24.5	—	—
Ocean station:	Bravo	4.02	9.67	10.7	—	—	—	—	—	—	—	—	—
	Charlie	[b] 3.92	—	11.5	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	3.20	7.92	14.6	34.3	137	83.7	127	—	43.8	20.1	11.2	6.44
Ocean station:	Delta	5.08	9.93	70.5	—	—	—	—	—	—	—	—	—
N.Y:	New York City	5.68	—	19.4	53.8	—	128	—	—	59.3	29.8	11.6	10.7
Va:	Sterling	7.45	—	23.5	53.1	57.1	158	134.	—	54.3	24.9	13.5	8.84
Ocean station:	Echo	5.82	11.8	21.3	—	—	—	—	—	—	—	—	—
Fla:	Miami	15.3	—	46.8	79.9	108	68.6	102	67.2	19.3	25.0	23.3	22.9
Bahamas:	Bimini	12.5	27.8	56.4	139	115	73.5	130	71.8	26.3	24.9	29.1	35.6
Hawaii:	Mauna Loa	21.9	35.9	79.2	234	329	228	155	67.0	36.7	46.9	22.2	27.8
P.R:	San Juan	7.21	26.8	42.3	90.2	[b] 78.0	91.0	109	57.8	18.1	14.0	12.7	17.6
Panama:	Balboa	6.99	18.8	24.6	49.7	33.3	11.0	20.9	5.62	1.71	4.82	3.16	8.45
Ecuador:	Guayaquil	53.2	27.8	6.96	4.87	3.67	4.08	7.18	3.31	4.92	4.77	4.42	4.14
Peru:	Lima	139	92.2	44.0	22.3	—	15.6	23.6	18.6	16.1	31.2	13.4	82.9
Bolivia:	Chacaltaya	35.2	26.1	13.4	12.1	26.3	25.4	44.0	29.8	15.1	9.92	[b] .32	4.47
Chile:	Antofagasta	120	79.2	54.9	29.4	18.8	—	29.5	—	—	11.8	8.21	19.5
	Portillo	633	429	—	—	—	—	—	—	—	—	—	—
	Santiago	123	96.2	70.1	42.7	24.9	29.3	29.4	—	22.6	26.7	9.05	6.70
	Puerto Montt	81.6	61.5	55.6	32.9	21.8	13.2	13.1	11.8	8.53	6.20	4.30	—
	Punta Arenas	30.4	—	33.8	13.6	10.1	6.38	9.30		4.98	3.65	2.67	(c)

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
[c] Error greater than 100 percent.
—, no data reported.

according to latitude beginning with the most northern site at Thule, Greenland (table 1).

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products and on the following dates for the induced radionuclides, maganese-54 and iron-55, October 15, 1961; cadmium-109, July 9, 1962.

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

Three quality control samples are submitted along with each monthly shipment of samples for analysis. A weighed aliquot of a standard solution of a nuclide to be analyzed is added to two of these filters and the third filter serves

Table 5. Cesium-137 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	5.72	5.86	8.13	—	3.87	2.03	5.14	—	3.46	4.91	—	—
Ocean station:	Bravo	2.60	4.71	4.14	—	—	—	—	—	—	—	—	—
	Charlie	3.03	—	3.69	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	4.73	5.20	8.75	10.6	8.71	8.60	13.0	—	6.77	3.53	2.74	2.27
Ocean station:	Delta	3.20	4.05	16.2	—	—	—	—	—	—	—	—	—
N.Y:	New York City	6.79	—	9.78	11.2	15.5	—	—	—	12.7	4.28	2.95	2.66
Va:	Sterling	5.40	—	9.12	8.68	14.3	14.2	11.8	—	7.77	4.86	3.33	2.84
Ocean station:	Echo	3.75	5.21	4.65	—	—	—	—	—	—	—	—	—
Fla:	Miami	7.70	—	13.2	8.27	7.58	5.34	8.57	7.52	3.29	5.79	5.36	7.51
Bahamas:	Bimini	7.00	9.85	9.78	11.9	8.75	5.01	11.2	8.30	3.23	4.01	6.42	9.33
Hawaii:	Mauna Loa	7.55	5.88	7.82	13.3	17.2	15.2	13.9	7.58	5.83	6.55	3.94	4.39
P.R:	San Juan	3.37	6.99	7.59	7.60	6.14	7.52	10.9	6.38	2.88	2.17	2.68	4.26
Panama:	Balboa	2.03	4.03	3.60	4.65	2.34	.78	2.20	.51	.33	.79	.66	1.86
Ecuador:	Guayaquil	3.16	2.41	.79	.60	.71	.76	1.66	.96	1.34	2.91	2.75	3.72
Peru:	Lima	7.65	8.02	4.36	3.01	—	2.65	6.15	5.04	7.57	16.1	10.7	7.11
Bolivia:	Chacaltaya	1.92	1.87	1.23	1.40	3.16	4.36	10.0	6.85	4.59	5.37	[b] .08	2.30
Chile:	Antofagasta	5.83	5.90	5.81	3.89	3.40	—	6.66	—	—	7.30	6.68	20.7
	Portillo	35.1	34.5	—	—	—	—	—	—	—	—	—	—
	Santiago	7.63	9.25	9.13	5.84	5.29	7.10	9.96	—	11.2	10.2	—	5.88
	Puerto Montt	4.48	4.77	5.34	4.37	3.86	3.01	3.52	3.84	3.12	3.91	2.62	—
	Punta Arenas	1.90	—	3.63	1.73	1.86	1.46	2.80	—	1.91	2.29	1.49	1.58

[a] Errors are less than 20 percent except:
[b] Error between 20 and 100 percent.
—, no data reported.

Table 6. Cerium-144 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	—	32.4	40.0	—	25.8	19.3	61.9	—	48.9	58.5	—	—
Ocean station:	Bravo	15.1	26.0	21.9	—	—	—	—	—	—	—	—	—
	Charlie	16.2	—	21.9	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	24.4	27.5	42.7	62.3	61.4	84.2	171	—	86.2	52.0	29.9	21.8
Ocean station:	Delta	20.7	26.7	99.3	—	—	—	—	—	—	—	—	—
N.Y:	New York City	27.8	—	43.6	63.7	109	103	—	—	140	63.0	31.4	32.2
Va:	Sterling	30.0	—	46.4	60.8	114	170	158	—	105	60.5	37.9	30.1
Ocean station:	Echo	22.6	29.0	32.9	—	—	—	—	—	—	—	—	—
Fla:	Miami	47.8	—	69.9	65.7	93.8	70.3	93.1	106	38.1	48.5	55.7	73.6
Bahamas:	Bimini	41.1	52.5	67.3	89.4	86.6	67.4	153	124	50.6	50.4	71.5	98.5
Hawaii:	Mauna Loa	42.3	36.5	55.7	155	229	204	181	102	72.3	76.7	41.8	46.3
P.R:	San Juan	18.3	38.1	48.5	65.1	67.4	91.3	124	95.0	36.3	23.5	—	43.2
Panama:	Balboa	13.4	25.9	25.1	37.0	26.1	9.67	26.2	8.80	3.55	6.98	6.01	18.0
Ecuador:	Guayaquil	51.0	32.0	9.0	7.19	8.21	9.3	20.0	15.2	16.6	27.8	23.3	36.3
Peru:	Lima	120	118	61.6	40.2	—	32.3	70.4	67.1	77.0	170	95.2	57.9
Bolivia:	Chacaltaya	28.9	28.6	17.0	16.4	39.1	52.0	103	79.0	55.3	51.8	.79	18.9
Chile:	Antofagasta	102	89.5	78.9	42.5	43.9	—	73.0	—	—	71.5	59.5	196
	Portillo	634	460	—	—	—	—	—	—	—	—	—	—
	Santiago	119	134	117	60.4	62.4	82.2	82.6	—	116	98.2	66.2	67.1
	Puerto Montt	66.3	69.9	72.9	56.3	45.8	31.8	25.2	43.8	38.1	40.0	21.9	—
	Punta Arenas	26.8	—	45.6	22.1	20.4	16.2	28.0	—	21.9	18.9	13.0	12.8

[a] Errors are less than 20 percent.
—, no data reported.

as a blank. The pattern of additions is varied for each nuclide so that different filters are blank for different nuclides.

All of the values reported by the contractor are corrected for a reagent blank, so that the blank values reported here reflect the contamination of the filter material both during manufacture and during handling at HASL and at the contractor laboratory.

Table 9 lists the results of the analyses of the blanks for each nuclide. In general, these data indicate low levels of contamination for most of the nuclides. The average plutonium-238 blank, which rose from 0.04 dpm in 1967 to 0.22

Table 7. Plutonium-238 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth) ×100											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	1.60	2.81	3.73	4.16	1.80	0.83	[b] 0.83	1.98	[b] 1.49	([c])	—	—
Ocean station:	Bravo	2.31	2.28	3.54	—	—	—	—	—	—	—	—	—
	Charlie	1.74	—	2.65	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	1.81	2.25	3.69	5.73	4.38	3.40	2.94	4.03	[b] 1.68	2.76	[b] 1.12	[b] 0.90
Ocean station:	Delta	2.09	1.33	6.61	—	—	—	—	—	—	—	—	—
N.Y:	New York City	3.51	2.98	4.52	7.81	6.31	5.67	—	3.57	2.55	1.46	.91	0.91
Va:	Sterling	4.04	—	4.07	7.66	[b] 9.22	4.19	[b] 4.59	2.48	[b] .89	1.31	[b] .72	[b] .78
Ocean station:	Echo	5.23	3.10	9.52	—	—	—	—	—	—	—	—	—
Fla:	Miami	3.12	—	4.39	4.23	4.17	[b] 1.44	[b] 1.96	2.19	[b] 1.50	1.09	1.92	[b] 1.03
Bahamas:	Bimini	2.79	3.86	4.71	5.94	3.04	[b] 1.15	[b] 1.67	1.41	[b] .68	[b] .37	[b] .93	[b] 2.08
Hawaii:	Mauna Loa	2.94	2.82	3.42	5.58	5.95	4.14	2.57	1.76	[b] 1.55	1.53	2.23	[b] 3.31
P.R:	San Juan	1.41	3.33	4.82	3.00	1.92	3.22	3.38	[b] 1.72	[b] .47	[b] .73	[b] .50	[b] 1.28
Panama:	Balboa	[b] .69	2.12	.84	2.18	[b] 1.67	[b] .26	.81	[b] 0.71	[b] .72	[b] .63	[b] .19	[b] .32
Ecuador:	Guayaquil	2.44	1.66	.75	.67	[b] .41	[b] .48	[b] 1.28	([c])	[b] 1.06	[b] .93	[b] 1.76	2.01
Peru:	Lima	5.47	5.81	3.20	2.08	1.21	[b] 1.86	3.34	[b] 2.99	3.42	9.16	[b] .89	3.19
Bolivia:	Chacaltaya	[b] 1.67	1.67	1.11	.99	2.66	3.01	3.38	3.44	[b] 1.24	2.76	([c])	[b] 1.62
Chile:	Antofagasta	[b] 4.10	3.31	3.86	2.84	1.87	—	[b] 3.31	—	—	3.67	3.99	9.43
	Portillo	24.3	23.2	—	—	—	—	—	—	—	—	—	—
	Santiago	[b] 5.72	6.85	6.45	4.54	3.56	11.8	5.65	1.22	[b] 4.71	6.11	—	4.16
	Puerto Montt	4.46	3.31	3.65	3.46	2.45	1.75	1.91	2.56	[b] 1.32	2.19	[b] 1.00	—
	Punta Arenas	[b] 1.78	—	2.99	1.50	1.29	1.06	1.50	.84	3.49	[b] .86	[b] .93	[b] .96

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent
[c] Error greater than 100 percent.
—, no data reported.

Table 8. Plutonium-239 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth) ×100											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	9.02	9.17	12.7	12.0	5.32	3.16	7.26	14.1	4.96	7.17	—	—
Ocean station:	Bravo	4.05	6.96	7.21	—	—	—	—	—	—	—	—	—
	Charlie	4.90	—	6.77	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	6.97	7.65	13.5	18.2	13.6	11.7	15.7	18.6	8.82	19.0	3.18	2.69
Ocean station:	Delta	5.62	5.80	31.0	—	—	—	—	—	—	—	—	—
N.Y:	New York City	12.0	7.94	15.6	20.3	21.2	19.2	—	22.2	14.0	7.00	3.76	4.40
Va:	Sterling	8.28	—	13.7	15.1	22.7	17.1	[b] 14.5	16.0	10.2	6.48	3.80	4.07
Ocean station:	Echo	5.36	7.81	10.2	—	—	—	—	—	—	—	—	—
Fla:	Miami	14.1	—	20.0	13.7	13.4	6.43	11.5	9.88	3.68	5.30	6.91	9.85
Bahamas:	Bimini	11.7	13.9	16.6	15.0	12.0	7.30	16.0	11.6	4.94	6.00	8.03	17.1
Hawaii:	Mauna Loa	11.5	8.92	11.5	21.7	24.5	20.1	16.7	10.0	6.18	8.15	3.75	7.47
P.R:	San Juan	5.07	9.50	12.4	9.49	7.20	9.75	13.1	16.5	3.59	2.28	3.53	5.38
Panama:	Balboa	[b] 2.85	7.41	4.72	5.76	3.07	.94	2.13	6.06	[b] .36	[b] .71	[b] .57	2.87
Ecuador:	Guayaquil	1.64	[b] .79	.60	.56	[b] .49	.77	[b] .68	[b] 1.50	[b] 2.78	2.48	2.73	4.77
Peru:	Lima	4.06	3.41	2.40	1.78	1.57	[b] 1.91	5.82	[b] 6.41	6.78	14.5	11.1	6.35
Bolivia:	Chacaltaya	[b] .98	1.03	.70	.99	2.22	4.61	7.53	7.45	5.13	4.66	[b] .21	2.63
Chile:	Antofagasta	[b] 2.44	2.82	2.73	2.22	2.28	—	6.50	—	—	6.80	6.53	20.3
	Portillo	16.9	16.1	—	—	—	—	—	—	—	—	—	—
	Santiago	[b] 4.18	4.28	4.38	3.89	3.81	6.02	6.60	2.30	12.2	9.82	—	8.81
	Puerto Montt	[b] 2.54	2.33	2.73	2.37	2.48	1.92	2.73	3.63	3.19	3.54	2.20	—
	Punta Arenas	[b] .71	—	1.53	[b] .89	1.06	0.97	1.74	1.14	4.38	2.01	1.80	[b] .80

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
—, no data reported.

Table 9. Quality control results on blank samples, 1969
(values in dpm/sample ± standard deviation)

Date (1969)	Strontium-89	Strontium-90	Zirconium-95	Cesium-137	Cerium-144	Plutonium-238	Plutonium-239
January	NA	2.6 ±1.7	5.9 ±6.9	0.4 ±0.4	2.0 ±1.9	0.5 ±0.06	0.02 ±0.02
February	19 ±137	2.5 ± .6	58.9 ±69	.9 ± .6	1.7 ±4.4	.2 ± .04	.06 ± .04
March	87 ±114	1.6 ±1.3	0 ±45	.4 ± .5	4.5 ±4.2	1.20 ±0.1	.04 ± .04
April	NA	1.1 ± .5	16.8 ±12.7	1.3 ±7.9	17.0 ±3.0	.05 ± .05	.0 ± .02
May	NA	.47 ± .20	4.3 ± 8.0	1.3 ±1.0	1.2 ±2.4	.15 ± .06	.0 ± .04
June	NA	NA	7.6 ± 5.5	.9 ± .6	47.0 ±4.7	.11 ± .07	.01 ± .04
July	3.6 ± 5.7	.2 ± .8	18.3 ± 9.0	.4 ± .7	1.2 ± .5	.3 ± .05	.0 ± .01
August	28 ± 39	.0 ± .3	1.5 ± 8.4	.5 ± .4	2.3 ±3.1	.01 ± .02	.0 ± .01
September	.0 ± 8.6	.9 ±1.3	1.5 ± 6.4	.3 ±1.3	2.4 ±2.0	.0 ± .02	.0 ± .02
October	1.0 ± 3.7	.4 ± .3	9.1 ± 9.5	.9 ±2.8	3.2 ±2.6	.05 ± .04	.01 ± .01
November	.0 ± 3.5	.1 ± .7	3.8 ± 5.9	.3 ± .3	2.7 ±2.0	.03 ± .04	.04 ± .03
December	.5 ± 2.6	.7 ± .3	3.1 ± 5.3	.8 ± .8	.8 ±2.1	.03 ± .06	.40 ± .04

NA, no analysis.

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Table 10. Quality control results on standard samples, 1969
(average values in percent deviation)

Date (1969)	Strontium-89	Strontium-90	Zirconium-95	Cesium-137	Cerium-144	Plutonium-238	Plutonium-239
January	NA	11.6	−21.8	3.5	13.7	−2.5	−42.9
February	33.9	−8.0	−14.5	− .8	13.9	19.0	11.7
March	7.5	−8.5	−19.3	−1.9	14.0	17.4	−19.9
April	NA	.0	7.0	5.0	−4.9	−2.0	−6.5
May	NA	−2.0	−9.9	5.8	5.4	−5.3	−6.1
June	NA	1.2	−7.0	24.1	4.5	−2.9	−7.8
July	−12.1	−14.0	−7.9	− .7	3.4	.7	17.7
August	−1.0	−6.0	39.0	−3.1	5.2	66.9	60.0
September	−3.5	4.8	−5.6	−4.1	7.7	33.4	37.0
October	−14.0	−10.8	−8.8	−3.6	3.6	5.4	1.6
November	.4	−2.1	−11.5	.8	3.0	5.3	3.3
December	−7.6	−6.8	−12.6	4.6	3.3	1.5	−2.1

NA, no analysis.

dpm in 1968, remained at this level in 1969, however, this was mainly because of the anomolously high value in March 1969. Because the amount of plutonium-239 found in surface air samples is frequently in the range of 1 dpm, this blank may represent a significant fraction of the total activity.

The results of analyses on standard samples are shown in table 10. These data are indicative of the accuracy of the radiochemical analyses. The values shown are the average percent deviations between the added activities and the results reported by the contractor. Although most of the results are satisfactory, the August and September 1969 deviations for both plutonium isotopes are extremely high. The very low blank values during these months indicate no plutonium contamination. The plutonium-238 to plutonium-239 and plutonium-239 to strontium-90 ratios for actual samples collected during these months are all reasonable and therefore there is no reason to suspect that they are in error, however, no explanation can be offered to account for these poor quality control results.

Recent coverage in *Radiological Health Data and Reports:*

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1968, 1969, and 1970[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since 1960, measurements of the strontium-90 content of foods and estimates of the daily intake of strontium-90 at New York City, Chicago, and San Francisco have been made by the Health and Safety Laboratory (HASL). Since 1961, measurements of the strontium-90 content of human vertebrae obtained for HASL by cooperating pathologists at the three cities have also been made. In 1968, sampling in Chicago was discontinued. Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium-90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism, especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

A listing of the results obtained as part of this program through 1964, along with an interpretation of the data was given earlier (*1*). Results of the analyses of samples obtained in 1965 and 1966 were previously reported (*2,3*).

The average strontium-90 concentrations observed in 1968 appeared to be only slightly less than those observed in 1967. As in previous years, the strontium-90 to calcium ratios of vertebrae from San Francisco were lower than those from New York City, reflecting the lower strontium-90 content of the diet in San Francisco as compared to New York City. Results of the analyses of samples obtained during 1968 are summarized in table 1.

Table 1. Strontium-90 to calcium ratios in human vertebrae, 1968

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
<1 month	—	ᵃ0.68 (20)
1 month–1 year	3.25 (8)	1.84
1–2	3.56 (4)	1.09 (5)
2–3	—	—
3–4	—	—
4–5	4.45 (3)	1.46
5–6	3.97 (3)	—
6–7	—	1.42 (4)
7–8	2.72 (3)	—
8–9	3.64	.85
9–10	1.97 (2)	1.57
10–11	2.89 (2)	—
11–12	—	1.30 (2)
12–13	—	—
13–14	3.16 (2)	—
14–15	3.76	1.76 (2)
15–16	3.36 (5)	.85
16–17	3.01 (6)	—
17–18	3.03 (4)	—
18–19	3.19 (5)	1.23 (2)
19–20	2.31 (5)	—
20–30	1.97 (8)	1.58 (2)
30–40	1.70 (5)	1.52 (3)
40–60	1.94 (5)	1.17 (8)
>60	1.83 (15)	1.13 (10)

ᵃ Number in parentheses indicates number of specimens.

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[1] Summarized from Fallout Quarterly Summary Reports, HASL-210 (July 1, 1969); HASL-227 (July 1, 1970) and HASL-243 (July 1, 1971).

The 1969 bone strontium-90 levels for New York City were about two times higher than those for San Francisco, reflecting the higher levels of strontium-90 in the New York City diet. In general, the bone levels for all ages in New York City in 1969 were about 25 percent lower than in 1968. The San Francisco data, on the other hand, indicate no obvious change between 1968 and 1969. Children's bone continued to show strontium-90 levels about one and one-half to two times higher than adults in both cities. Results of the analyses of samples obtained during 1969 are summarized in table 2.

Table 2. Strontium-90 to calcium ratios in human vertebrae, 1969

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0–1 month		0.6 (61)
1–2		1.0 (6)
2–5		1.7 (6)
6–1 year		2.2 (7)
0–1 year	[a] 2.6 (23)	
1–2	2.7	1.6 (5)
2–3	3.2 (2)	1.2 (5)
3–4	3.6	1.5 (4)
4–5	2.8 (2)	1.0 (2)
5–6	2.4	1.8 (3)
6–7	2.2 (2)	1.1 (2)
7–8	—	—
8–9	1.7	1.5 (3)
9–10	2.3 (3)	—
10–11	—	—
11–12	2.4	1.1 (2)
12–13	2.8	1.1
13–14	2.7 (4)	—
14–15	2.9 (3)	1.4 (2)
15–16	2.4 (2)	1.3
16–17	3.2 (2)	1.1
17–18	2.2 (8)	1.4 (4)
18–19	2.0	.8 (2)
19–20	—	—
20–30	1.7 (10)	1.0 (11)
30–40	1.4 (6)	.8 (13)
40–50	—	.9 (16)
50–60	1.9 (4)	.9 (25)
60–70	2.0 (5)	1.0 (15)
70–90	1.7 (4)	.8 (4)

[a] Number in parenthesis indicates number of samples (HASL-227).

The average values and standard deviations for New York and San Francisco adult vertebrae in 1970 were 1.55 ± 0.36 pCi ^{90}Sr/g Ca and 0.86 ± 0.30 pCi ^{90}Sr/g Ca, respectively. These values represent decreases of 13 percent in New York City and 8 percent in San Francisco from the average values of the previous year.

The strontium-90 to calcium ratios for children showed more variation than the adult values and generally higher values were obtained for children than adults. The highest values in both cities were for infants between the age of 4 months and 2 years. Results of the analyses of samples obtained during 1970 are summarized in table 3.

Table 3. Strontium-90 to calcium ratios in human vertebrae, 1970

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0–1 month		0.72 (58)
1–2		.89 (6)
2–3		1.73 (4)
4–9		2.14 (6)
0–9	[a] 2.47 (12)	
1–2 year	2.77	1.71 (5)
2–3	—	.95
3–4	2.35	1.05 (3)
4–5	—	.85
5–6	1.87	—
6–7	—	—
7–8	—	.86
8–9	—	—
9–10	1.85	1.19
10–11	—	1.33
11–12	—	1.16
12–13	1.94	1.22
13–14	2.47	1.60 (2)
14–15	1.89 (2)	.68
15–16	—	.66
16–17	1.38	.47
17–18	2.27 (3)	—
18–19	2.72 (4)	1.55 (2)
19–20	1.84 (6)	1.24 (2)
20–30	1.58 (13)	.96 (4)
30–40	1.44 (6)	.95 (7)
40–50	1.36 (5)	.80 (9)
50–60	1.57 (5)	.78 (16)
60–70	1.49 (10)	1.09 (9)
70–80	1.82 (9)	.89
80–90	1.41 (4)	—

[a] Number in parenthesis indicates number of samples.

Bone model

The model previously used by Rivera (*1*) to correlate the strontium-90 concentrations in diet and bone is described by the equation:

$$Ca_n X_n = Ca_{n-1}(1-F) X_{n-1} + Ca_{n-1}(F+R-1) KZ_{n-1}$$

where

Ca_n = Calcium content of the skeleton in the year n,

X_n = Strontium-90/calcium ratio in bone in the year n,

$R = Ca_n/Ca_{n-1}$

Z_{n-1} = average strontium-90 to calcium ratio in the diet, usually taken from midyear of the year n-1 to midyear of the year n. The X_{n-1} should contain correction for radioactive decay. The parameters F and K are determined by fitting the equation to the observed survey data. The factor F describes the bone turnover rate, or perhaps more appropriately, the effective strontium removal rate during the period n-1 to n. K is the bone-diet observed ratio.

The model is admittedly quite simple, in that only a single exponential removal rate of strontium from bone is assumed, even though this rate is allowed to vary with age. Undoubtedly, several processes of removal are proceeding with variable rates in various types of bone and at various locations within bone and on the surfaces. The model also assumes no reutilization of dissolved bone minerals. Thus, because of these simplifications in the model, some reservation must be made in assigning physiological significance to the parameters derived. The model, however, provides a useful empirical relation for describing the bone levels measured over the past years and for making short term predictions of future levels.

Rivera has previously applied multiple linear regression analysis to the New York City data for the periods, 1961–1965 (*1*) and 1961–1968 (*4*) to obtain estimates of the factors F and K. The data through 1970 and also the data from San Francisco have now been included in the analysis. The San Francisco data are comparable to the New York data, but the lower levels of strontium-90 concentrations in diet and bone provide a different situation from New York. Compromises are needed in the selection of the parameters to fit both the New York and San Francisco data, but more generally applicable results are obtained.

Regression results

The period through 1965 was a time of generally increasing concentrations of strontium-90 in bone. The New York data for this period were adequately fit by assuming a bone turnover rate of 72 percent per year for age 0–1 year, decreasing to about 20 percent per year at age 4–5 years. The turnover rate increased between 6–12 years and again during the late teenage years. For adult bone, an annual turnover rate of 8 percent and an observed ratio of 0.25 were assumed.

Since 1965, the bone levels have been decreasing at relatively rapid rates, more rapidly than would be inferred from the turnover rates derived for the periods of increasing bone levels. The turnover rates derived from the 1961–1968 and the 1961–1970 New York data are little different from one another, but are generally higher than previously determined. The survey data for all ages can be adequately fit by using these most recently derived values for the turnover rates and observed ratios.

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(*3*) RIVERA, J. Strontium-90 in human vertebrae-1966 results, HASL–182, p. I–10. U.S. Atomic Energy Commission (July 1967).

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Offsite Surveillance Around the Nevada Test Site January-June 1966 [1]

Western Environmental Research Laboratory,[2]
EPA, and Nevada Operations Office, AEC

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission, the Western Environmental Research Laboratory (WERL), formerly the Southwestern Radiological Health Laboratory, conducted its continuing program of radiological surveillance, including monitoring and environmental sampling, in the public areas surrounding the Nevada Test Site (NTS) from January through June 1966. During this period, 29 announced underground nuclear tests were conducted at the NTS and nine Experimental Plans of the NRX-A4 EST and NRS-A5 nuclear rocket engine series were conducted at the Nuclear Rocket Development Station (NRDS), a part of the NTS complex.

Operational procedures

Comprehensive ground monitoring capabilities were maintained throughout the period. Mobile ground monitoring teams were positioned in offsite areas prior to each event. Each monitor was equipped with an Eberline E-500B survey meter, a Baird-Atomic Model NE-148A Scintillator, and Victoreen Radector, Model No. AGB-50B-Sr. Eberline RM-11 gamma-rate recorders were also available to document cloud passage at fixed ground locations. An Air Force U-3A aircraft with two WERL monitors was used for tracking airborne radioactivity to aid in the positioning of ground monitors. Two WERL aircraft were utilized as necessary for cloud sampling by cryogenic, electrostatic precipitator, and mass air sampling techniques.

The WERL Air Surveillance Network (ASN) consisted of 106 stations operating in every State west of the Mississippi River except Montana and North Dakota. The air sampler used was a Gelman "Tempest" which was equipped to use a 4-inch-diameter Whatman 541 filter paper and MSA charcoal cartridge.

In addition to air sampling, milk, water and vegetation samples were collected and analyzed. The routine milk sampling program was continued throughout the 6-month period, collecting 135 samples from both commercial dairies and private producers. Three hundred and fifty-eight water samples were collected from 76 sources of both potable and nonpotable supplies. Vegetation samples were collected after the nine releases of radioactivity to delineate any fallout pattern.

Approximately 150 residents in the offsite area wore film badge dosimeters during this period and 1,900 station badges were also distributed among the dosimetry station network. The DuPont type 545 film in the badge has a 30 mR lower limit of detection. Three EG&G Model TL-12 thermoluminescent dosimeters (TLD's) were used at each of 20 dosimetry stations.

A WERL medical officer was available to investigate cases of medical nature which might have occurred as a result of the nuclear testing. Similarly, a WERL veterinarian was available to conduct wildlife or domestic livestock investigations.

Analytical procedures

Samples were returned to the WERL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma-emitting isotopes; a 4- by 4-inch NaI (Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer was used. The lower

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[1] This article is a summary of report No. SWRHL-37r, Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1966.

[2] Formerly part of U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

Table 1. Five highest air sampling results in off-Nevada Test Site areas January-June 1966

Date and time (Pdt) (on/off)	Location	Gross beta radioactivity (pCi/m^3)	Radionuclide analysis (pCi/m^3)	
			Iodine-131	Iodine-133
April 25 1413/1700	6.5 miles W of Hancock Summit	50,000	3,500 (P)[a] 150 (C)[b]	4,100 (P) 500 (C)
April 25 1400/1535	18 miles NE of Groom Lake	45,000	5,100 (P) 290 (C)	12,000 (P) 880 (C)
April 25 1435/1745	Hancock Summit	34,000	2,600 (P) 170 (C)	3,000 (P) 660 (C)
April 25 1430/1755	Ash Springs, Nev.	25,000	5,300 (P) 130 (C)	5,600 (P) 290 (C)
April 25 1430/1810	Hiko Crystal Springs	21,000	1,600 (P) 400 (C)	1,900 (P) 800 (C)

[a] P—Whatman-541 particulate filter.

[b] C—MSA charcoal cartridge, secondary to particulate filter, for collection of radioactive gases, primarily iodine.

limit of detection for gamma emitters in milk samples was 20 pCi/liter at the time of count. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight radionuclides. Analyses for strontium-89 and strontium-90 were performed on selected samples.

Results

Three underground tests released radioactivity which was detected in offsite areas. These were the Red Hot Event on March 5, the Pin Stripe Event on April 25, and the Double Play Event on June 15. In addition, effluent was released to the offsite area during execution of Experimental Plans IIB, III, IV, and IVA of the NRX–A4/EST reactor test series, conducted on February 3, March 3, 16, and 25, respectively, and Experimental Plans III and IV of the NRX–A5, conducted on June 8 and 23. The highest levels of radioactivity measured offsite during this period are shown in tables 1 through 4. The highest ground monitoring reading at a populated area was 1.5 mR/h taken at Hiko at 1600 hours Pdt April 25, following the Pin Stripe Event. Pin Stripe also contributed the highest results found in air samples, milk samples, and potable water. There were no positive exposures on personnel film badges during this 6-month period.

A special innovation was introduced during this period to keep radioiodine levels in milk as low as possible. In regard to the ranches and dairies listed in table 2, all milk produced by family cows at the Davis, Donahue, and Sharp Ranches was taken for sampling purposes.

Table 2. Five highest radioiodine levels in milk samples in off-Nevada Test Site areas, January-June 1966

Date	Location	Iodine-131 concentration (pCi/liter)
April 27	Schofield Dairy, Hiko, Nev.	4,800
April 27	Davis Ranch, Hiko, Nev.	3,500
April 28	Sharp Ranch, Alamo, Nev.	2,100
April 28	L. Lee Dairy, Alamo, Nev.	1,400
April 28	Donahue Ranch, Ursine, Nev.	1,100

Uncontaminated milk and dairy products were substituted in lieu of cash payments. At the Schofield Dairy, stored hay from Utah was purchased and substituted for the green chop being fed at that time. Milk from the Lee Dairy and the Schofield Dairy was diluted with uncontaminated milk from dairies outside the affected areas. The substitution of dry hay kept radioiodine levels low and also provided experimental data for future planning purposes.

Table 3. Five highest potable water sample results in off-Nevada Test Site areas, January–June 1966

Location	Collection date	Iodine-131 concentration (pCi/liter)
Hiko, Davis Ranch	April 26	3,860
Ursine, McCrosky Ranch	May 2	360
Panaca, K. Lee Ranch	May 3	140
Ursine, Lytle Ranch	May 2	140
Caliente, Oxborrow Ranch	May 3	120

During the Pin Stripe Event, the WERL-designed thyroid dose assessment trailer was used for the first time under actual field conditions. Equipped with a 5- by 2-inch NaI crystal detector, a multichannel analyzer and proper shadow shielding, the trailer along with its pickup truck and generator constitutes a completely self-contained unit capable of determining actual thyroid dose in the field. Measurements were taken in locations determined from aerial surveillance and milk sampling data. Table 4 shows the results of total measurements taken.

Table 4. Number of people within a given range of computed thyroid dose, Pin Stripe Event

Location	Background	Background-50 mrad	50–150 mrad	150–300 mrad	Total
Alamo	10	17	6	0	33
Hiko	5	19	8	2	34
Ursine	4	1	0	0	5
Pioche	1	0	0	0	1
Panaca	5	0	0	0	5
Total	25	37	14	2	[a] 78

[a] Includes 37 male children and 33 female children.

Calculations were made on the basis of an inhaled dose after cloud passage. Although results were difficult to distinguish because of high background measurements and extremely low thyroid burdens, considerable information was gained in respect to the design and operation of the portable thyroid counter and the handling of public relations in obtaining the acceptance and cooperation of the offsite population.

Conclusion

In summary, three underground events and six reactor experiments released radioactivity to offsite areas. Of these, the Pin Stripe Event had the most apparent effect on the offsite environment, although radioactivity resulting from this event was detected in only negligible amounts in terms of established safety standards. Innovations in the development and use of surveillance equipment and control techniques were of particular significance.

Environmental radiation surveillance during this period indicates that no individual in the offsite area received an exposure resulting from NTS operations which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Atomics International, Los Alamos Scientific Laboratory and the Portsmouth Area Gaseous Diffusion Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Atomics International[2]

January-June 1971

North American Rockwell Corporation
Canoga Park, Calif.

Atomics International, a division of North American Rockwell Corporation, has engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is located in the Simi Hills of Ventura County, approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International requires adequate containment of radioactive materials and rigid operational controls to minimize effluent releases and external radiation levels. The environmental monitoring program provides a measure of the effectiveness of the company's radiological safety procedures and of engineering safeguards incorporated into facility designs.

The sites of the Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. The environs are sampled monthly, except for soil and vegetation which are sampled quarterly. Continuous environmental air monitoring at the sites provides information concerning long-lived airborne particulate radioactivity. A site perimeter radiation monitoring program using thermoluminescent dosimetry (TLD) was begun in 1971.

Counting and calibration procedures

The determination of radioactivity in all environmental soil, vegetation, water, and air samples is performed with a low-background proportional counting system capable of simultaneous counting of both alpha and net beta radioactivity. The sample-detector configuration provides a nearly 2π geometry. The thin-window detector is continually purged with methane counting gas. A preset time mode of operation is used for all samples; however, an overriding preset count mode is available to

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[2] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1971 to June 30, 1971," Atomics International, Division of North American Rockwell Corporation.

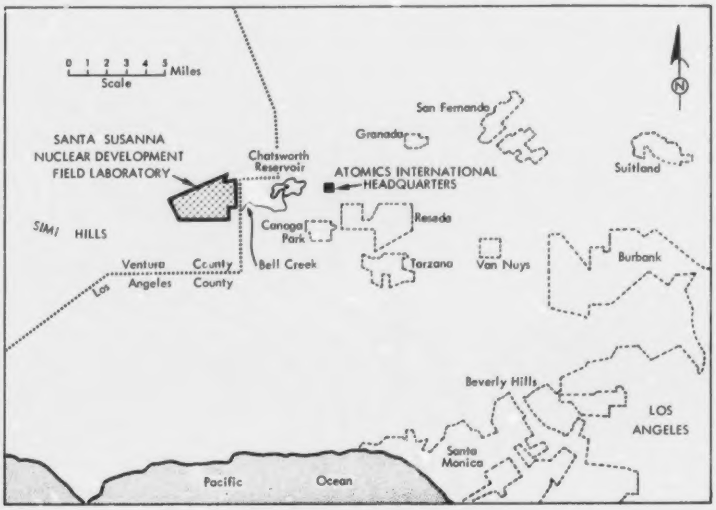
0 1 2 3 4 5 Miles
Scale
SANTA SUSANNA NUCLEAR DEVELOPMENT FIELD LABORATORY
SIMI HILLS
Chatsworth Reservoir
ATOMICS INTERNATIONAL HEADQUARTERS
San Fernando
Granada
Sunland
Canoga Park
Reseda
Bell Creek
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
Beverly Hills
LOS ANGELES
Santa Monica
Pacific Ocean
N

Figure 1. Atomics International facilities and vicinity

limit the counting time for high activity samples.

The minimum detection limits shown in table 1 were determined by using typical values for counting time, system efficiency, background count rates (approximately 0.05 cpm alpha and 1.0 cpm beta-gamma) and sample size. In addition, the minimum statistically significant amount of radioactivity, irrespective of sample configuration, is established as that amount equal in count rate to three times the standard deviation of the system background count rate.

Table 1. Minimum radioactivity detection limits, Atomics International

Sample	Radioactivity	Minimum detection limits (standard error)
Soil	Alpha	0.05 ±0.03 (pCi/g)
	Beta-gamma	.22 ± .11 (pCi/g)
Vegetation	Alpha	.10 ± .06 (pCi/g-ash)
	Beta-gamma	.35 ± .18 (pCi/g-ash)
Water	Alpha	.20 ± .12 (pCi/liter)
	Beta-gamma	.63 ± .32 (pCi/liter)
Air	Alpha	8.5 ±5.3 (fCi/m³)
	Beta-gamma	18 ±9.3 (fCi/m³)

Counting system efficiencies are determined routinely with RaD+E+F (with alpha absorber), thorium-230, and uranium-235 standard sources, and with potassium-40 in the form of standard reagent grade KCl, which is used to simulate soil and vegetation samples. Self-absorption standards are made by dividing sieved KCl into samples beginning with a 100 milligram sample and increasing in mass by 200-milligram increments from 200 to 3,000 milligrams. The samples are placed in copper planchets of the type used for environmental samples and counted. The ratio of sample activity to the observed net count rate for each sample is plotted as a function of sample weight (figure 2). The correction factor (ratio) corresponding to sample weight is obtained from the graph. The product of the correction factor and the net sample count rate yields the sample activity (dpm). This method has been proved usable by applying it to variously sized aliquots

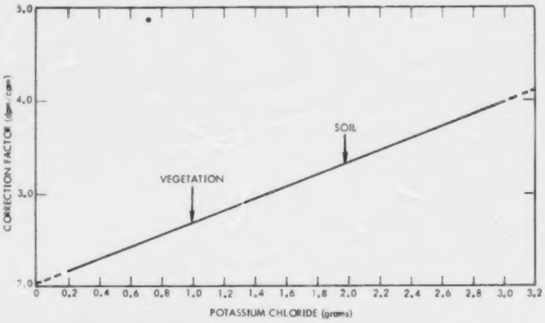

Figure 2. Sample self-absorption correction graph

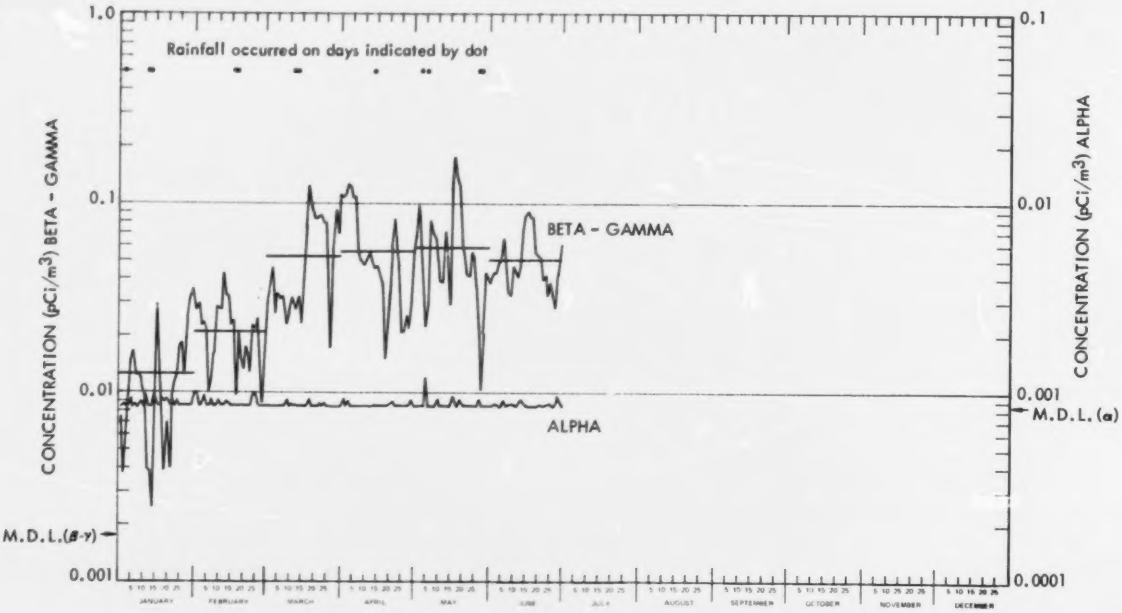

Figure 3. Long-lived radioactivity at headquarters and NDFL, January-June 1971

of uniformly mixed environmental samples and observing that the resultant specific activities fall within the expected statistical counting error.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic sequential air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 2.

When abnormally high airborne radioactivities are observed, the beta-gamma radioactivity decay data are plotted to determine the presence of short-lived isotopes other than naturally occurring radon, thoron, and daughters. If fallout is suspected, the decay characteristics are observed. If the radioactivity decays as a function of $t^{-1.2}$, the data curve is extrapolated in order to determine the date of origin. This date is compared with the dates of publicized nuclear detonations to determine if the abnormal airborne radioactivity was caused by such detonations.

A graph of averaged long-lived airborne radioactivity concentrations detected at the Headquarters and NDFL facilities during the first 6 months of 1971 is presented in figure 3.

Table 2. Radioactivity in air, Atomics International January–June 1971

Location	Radioactivity	Number of samples	Average concentration (fCi/m³)
Headquarters	Alpha	362	8.7
	Beta-gamma	362	400
NDFL	Alpha	1,249	8.6
	Beta-gamma	1,249	440

The graph shows a generally increasing trend in airborne beta-gamma radioactivity through the spring months with a prominent peak noted in May.

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 3.

Table 3. Process water radioactivity, NDFL site January–June 1971

Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.32
Beta-gamma	12	4.9

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek,[a] January–June 1971

Sample description	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir (station 6), water [a] (pCi/liter)	6	0.24	6.1
Reservoir (station 12), water [a] (pCi/liter)	6	.16	6.2
Bell Creek (station 54), mud (pCi/g)	6	.31	23
Bell Creek (station 54), vegetation (pCi/g ash)	6	.19	161
Bell Creek (station 16), water (pCi/liter)	6	.20	3.9

[a] Location not shown on figure 1.

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent Santa Susana Field Laboratory (SSFL) property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66-49, an environmental sampling station has been established in Bell Creek Canyon approximately 2.5 miles downstream from the south NDFL boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The lake was drained in July 1969 for construction, thereby precluding surface sampling for the current reporting period. The average radioactivity concentration in reservoir supply water samples is presented in table 5.

Table 5. Chatsworth Reservoir water radioactivity Atomics International, January–June 1971

Sample	Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	0	—
	Beta-gamma	0	—
Supply inlet	Alpha	6	0.48
	Beta-gamma	6	6.1

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 25 locations. Eleven sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 14 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of undisturbed ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 6.

Table 6. Radioactivity in the soil, Atomics International January–June 1971

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.57
	Beta-gamma	72	25
Offsite	Alpha	24	.55
	Beta-gamma	24	24

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 7.

Table 7. Radioactivity in vegetation, Atomics International January–June 1971

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.25
	Beta-gamma	72	165
Offsite	Alpha	24	.26
	Beta-gamma	24	134

External radiation

Site boundary radiation monitoring is performed with calcium fluoride thermoluminescent dosimeters (TLD) placed at selected locations on or near the perimeters of the Headquarters and NDFL sites. Each dosimeter, sealed in a lightproof plastic holder, is installed in a polyethylene vial which is permanently mounted at each monitoring location. The dosimeters are exchanged and analyzed quarterly. The radiation dose monitored at each dosimeter location is presented in table 8.

Table 8. External radiation dose, Atomics International January–June 1971

Location	Dose (mrem)	Average dose rate (μrem/h)
TLD-1	97	24
TLD-2	67	16
TLD-3	90	22
TLD-4	99	24
TLD-5	81	20
TLD-6	84	21
TLD-7	99	24
TLD-8	108	27
TLD-9 [a]	39	18
TLD-10	132	32

[a] Second quarter only.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1970	February 1971
July-December 1970	June 1971

2. Los Alamos Scientific Laboratory[3] Calendar Year 1970

University of California
Los Alamos, N. Mex.

As part of the environmental monitoring program at Los Alamos, measurements of beta radioactivity in airborne particulates and precipitation are made periodically. The samples have been taken on the roof of building TA-50 (about 1¾ miles southeast of the administration building) since March 1963.

Air monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The air sampling rate is 17.0 m^3/h. Air samples are ordinarily collected for 24-hour intervals during the work week, and weekend samples are collected for a 72-hour period.

The filters are counted for beta radioactivity 7 days after collection in a thin-window gas

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[3] Summarized from "Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1970" (La-4661).

Table 9. Beta radioactivity in air and precipitation, Los Alamos, January–December 1970

Month 1970	Air (pCi/m^3)			Deposition (pCi/m^2)			
	Maximum	Minimum	Average	Maximum	Minimum	Average	Total
January	0.10	0.02	0.06	72	1	12	369
February	.44	.06	.14	94	3	20	553
March	.32	.07	.18	559	3	105	3,258
April	1.01	.14	.42	673	2	64	1,993
May	1.19	.10	.38	452	11	63	1,972
June	.61	.16	.34	484	16	111	3,351
July	.30	.05	.12	555	5	125	3,865
August	.21	.03	.10	351	8	85	2,646
September	.14	.03	.08	643	5	83	2,491
October	.11	.01	.06	86	5	27	850
November	.28	.03	.10	72	2	16	496
December	.18	.05	.08	40	2	13	428

(methane) flow proportional counter with an overall efficiency of 50 percent for strontium-yttrium-90. A large chamber permits the air samples to be counted in the same geometry as the precipitation samples. The efficiency for strontium-yttrium-90 for the larger filter samples is also 50 percent.

Precipitation monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 2.5 mm of precipitation. It has been found that this arrangement collected radioactivity even during relatively dry periods. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. Samples are taken daily on workdays. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1-inch stainless-steel planchets, and counted in an automatic beta counting system, employing a gas-flow proportional alpha and beta chamber. A cosmic-ray umbrella with coincidence count-cancel provides a low background for the system. The counting efficiency is determined with a radiolead standard which emits 1.17 MeV beta particles.

Results

Average daily radioactivity concentrations in air are weighted for sample periods of more than 1 day. Average radioactivity concentrations for the precipitation collection are calculated from the total radioactivity collected during the month divided by the number of days in the month. Summary of air and precipitation data for January–December 1970 is presented in table 9.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1970	April 1971
July-December 1970	September 1971

3. Portsmouth Area Gaseous Diffusion Plant[4] January-June 1971

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha, beta, and gamma radiation, and it is assumed that the gross activity is due to enriched uranium and the beta-gamma radiation emanating from the thorium-234.

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[4] Data summarized from "Portsmouth Area Gaseous Diffusion Plant Environmental Radioactivity Levels and Concentrations, Semiannual Summary, First half 1971" (September 17, 1971).

Table 10. Radioactivity in air, Portsmouth Plant, January–June 1971

Location	Number of samples	Alpha radioactivity concentration (fCi/m³)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m³)			Average as a percent of AEC standards[a]
		Maximum	Minimum	Average		Maximum	Minimum	Average	
3	69	145	<16	32	0.80	1.66	<0.016	0.531	0.05
12	69	145	<16	32	.80	2.11	<.016	.531	.05
24	68	161	<16	32	.80	2.03	<.016	.564	.06
29	65	161	<16	32	.80	1.58	<.016	.515	.05
Summary	271	161	<16	32	.80	2.11	<.016	.538	.05

[a] The AEC radiation protection standard for alpha radioactivity in air–4 pCi/m³; beta-gamma radioactivity—1 nCi/m³; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m³.

Table 11. Radioactivity in water, Portsmouth Plant, January–June 1971

Location	Number of samples	Alpha radioactivity concentration (pCi/liter)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/liter)			Average as a percent of AEC standards[a]
		Maximum	Minimum	Average		Maximum	Minimum	Average	
1	6	13.5	0.5	4.1	0.01	31.5	6.8	13.5	0.07
2	6	63.0	.9	13.3	.04	18.0	6.8	8.6	.04
3[b]	6	3.2	.5	.8	.00	22.5	6.8	9.4	.05
4	6	13.5	.5	3.9	.01	58.5	6.8	19.9	.10
5	6	9.0	.5	4.4	.01	31.5	6.8	10.9	.05
6	6	10.8	.5	2.7	.00	81.9	6.8	21.2	.11
7	6	207	58.5	95.3	.32	1,410	104	644	3.22
8	6	122	36.0	78.8	.26	1,630	126	664	3.32
10[b]	6	9.0	.5	2.4	.00	49.5	6.8	15	.08
11[b]	6	329	99.0	208	.69	8,780	202	3,620	18.1
12	6	4	.5	1.3	.00	13.5	6.8	7.9	.04
13	6	31.5	.5	14.3	.05	266	6.8	104	.52
14	4	9.0	.5	4.4	.01	40.5	6.8	20.3	.10
Summary	76	329	0.5	33.4		8,780	6.8	397	

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis alpha radioactivity—0.5 pCi/liter; beta radioactivity—14.0 pCi/liter.
[b] Composite sample.

Air samples are collected three times each week at four locations. Each sample, consisting of approximately 1,000 cubic feet of air, is passed through a Whatman 41 filter paper at about 20 cubic feet per minute. The material collected on the filter paper is analyzed for gross alpha and gross beta-gamma activities.

Two sampling procedures are used for water analyses. One-half gallon samples are taken monthly from the Scioto River and its tributaries, Little Beaver Creek, Big Beaver Creek, and Big Run. Composite samples are collected continuously (or at specific intervals) from the three principal drainage ditches serving the plant; sampling locations are identified as points 3, 10, and 11 (figure 4). The composite samples are collected in 55-gallon drums. Once each month, the water in the drum is drained and installed again in the collection system. The one-half gallon samples are analyzed for average gross alpha and beta-gamma radioactivity concentrations.

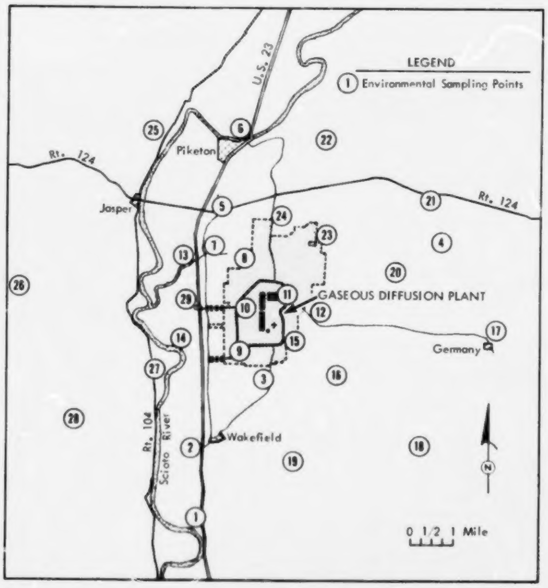

Figure 4. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

In addition to the water samples, external gamma radiation levels are measured routinely at locations 3, 12, 24, and 29. Measurements are made three times each week with a calibrated Geiger-Mueller tube at a distance 3 feet above ground level.

Average alpha and beta-gamma radioactivity concentrations in air are summarized in table 10. Table 11 contains the average alpha and beta-gamma radioactivity concentrations in water. The external gamma-ray level, measured at the sampling locations shown in figure 4, are summarized in table 12.

The maximum radioactivity in water is persistently found in samples taken from the east drainage ditch, sampling location 11; and the other high values are found in samples taken downstream from sample point 11.

Table 12. Background exposure rates, Portsmouth Plant, January–June 1971

Location	Number of samples	Background rate [a] (µrem/h)		
		Maximum	Minimum	Average
3	62	19.0	7.4	10.9
12	63	12.9	6.0	9.8
24	64	26.9	7.6	11.4
29	60	18.1	7.6	11.9
Summary	249	26.9	6.0	11.0

[a] Open-shield geiger tube 1 foot above ground; limit of sensitivity—0.1 µrem/h.

Sample location 11 is in the east drainage ditch before the ditch dumps into Little Beaver Creek. Sampling point 8 is in Little Beaver Creek a short distance above its confluence with the Big Beaver Creek; and sample location 7 is in Little Beaver Creek immediately above the confluence of the two creeks. Location 13 is in Big Beaver Creek below the confluence of Big Beaver and Little Beaver Creeks. Location 14 provides samples from the Scioto River after it is joined by Big Beaver Creek.

The samples taken from locations 7 and 8 would be expected to be quite similar, and indeed the radioactivity concentrations are similar. As one would expect then, the radioactivity concentrations decrease rapidly in going from point 11, through 7–8, through 13, and eventually to 14. Based on results from location 6 (in the Scioto River above its confluence with Big Beaver Creek) and location 14, it is evident that the Scioto River has not suffered pollution from the Portsmouth Gaseous Diffusion Plant.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	April 1971
July–December 1970	September 1971

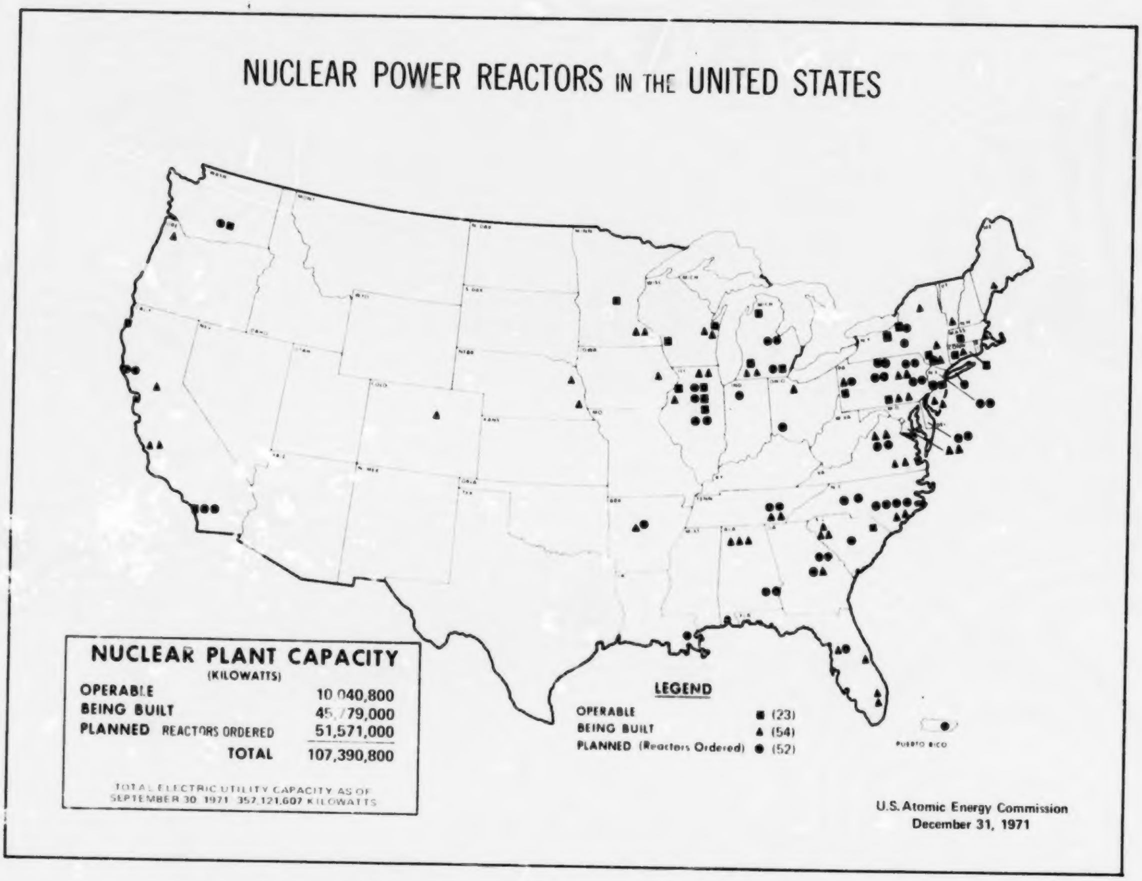
NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 10,040,800
BEING BUILT 45,779,000
PLANNED REACTORS ORDERED 51,571,000
TOTAL 107,390,800
TOTAL ELECTRIC UTILITY CAPACITY AS OF SEPTEMBER 30, 1971 357,121,607 KILOWATTS
LEGEND
OPERABLE ■ (23)
BEING BUILT ▲ (54)
PLANNED (Reactors Ordered) ● (52)
PUERTO RICO
U.S. Atomic Energy Commission
December 31, 1971

Figure 1. Nuclear power reactors in the United States, December 31, 1971

Nuclear Power Reactors in the United States
December 31, 1971

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of Radiation Data and Reports.

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,000	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generation Station	804,000	Sacramento Municipal Utility District	1973
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
DELEWARE				
•	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1979
•	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Red Level	Crystal River Plant: Unit 4	897,000	Florida Power Corp.	1978
Ft. Pierce	Hutchinson Island: Unit 1	800,000	Florida Power and Light Co.	1974
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
Hancock Landing	Alvin W. Vogtle, Jr. Plant: Unit 1	1,100,000	Georgia Power Co.	1978
Hancock Landing	Alvin W. Vogtle, Jr. Plant: Unit 2	1,100,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad Cities Station: Unit 1	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1971
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1976
•	—	1,100,000	Comm. Edison Co.	1978
•	—	1,100,000	Comm. Edison Co.	1979
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station: Unit 1	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	655,000	Boston Edison Co.	1972
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1962
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1974
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1976
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1977
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973

Figure 1. Nuclear power reactors in the United States, December 31, 1971—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	650,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1977
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N. J.	1973
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N. J.	1974
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,088,000	Public Service Electric and Gas, N. J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,088,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1972
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,100,000	Niagara Mohawk Power Co.	1977
Rochester	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Con. Ed. Nuclear #4	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N. Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
OREGON				
Prescott	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1975
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.-Ohio Edison Co.	1973
Shippingport	Beaver Valley Power Station: Unit 2	847,000	Duquesne Light Co.-Ohio Edison Co.	1978
Middletown	Three Mile Island Nuclear Station: Unit 1	831,000	Metropolitan Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 2	907,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1978
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1980
*	Philadelphia Electric Co.: HTGR No. 1	1,150,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co.: HTGR No. 2	1,150,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconne Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Parr	Virgil C Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	Hanford No. 2	1,110,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975

---

* Site not selected

*	--	1,175,000	Tennessee Valley Authority	1977
*	--	1,175,000	Tennessee Valley Authority	1978

Figure 1. Nuclear power reactors in the United States, December 31, 1971—continued

Reported Nuclear Detonations, January 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The Peoples Republic of China set off a nuclear explosion in the atmosphere at approximately 2:00 a.m., EST, on January 7, 1972, at their Lop Nor nuclear test area in northwest China. The yield was less than 20 kilotons.

There were no reported nuclear detonations for the United States for January 1972.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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☆U.S. GOVERNMENT PRINTING OFFICE: 1972—484-494/2

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EVALUATION OF TRITIUM IN GROUND AND SURFACE WATERS OF THE WESTERN UNITED STATES, APRIL 1968-DECEMBER 1969. *James W. Mullins and John L. Stein, Radiation Data and Reports, Vol. 13, February 1972, pp. 59–67.*

In order to establish a baseline for environmental tritium so that any future deviations could be evaluated, a study was conducted to measure current levels of tritium in ground and surface waters of the Western United States. Data are reported for tritium concentrations in surface and ground waters during April 1968-December 1969 in the Western United States including Alaska and Hawaii. Samples were collected by State public health agencies and mailed to the Western Environmental Research Laboratory where they were analyzed by liquid scintillation techniques. The concentration of tritium was nondetectable in most ground water samples, while other samples contained as much as 2.6 nCi/liter. Surface water samples ranged from nondetectable to 3.8 nCi/liter. Possible reasons for the range of results, such as altitude and latitude effects, are discussed.

KEYWORDS: Ground water, surface water, tritium, water, Western United States.

RADIATION DATA AND REPORTS

formerly **RADIOLOGICAL HEALTH DATA AND REPORTS**

Volume 13, Number 3, March 1972

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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Published under the direction of

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Acting Deputy Assistant Administrator
for Radiation Programs
Office of Radiation Programs

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U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Radioactive Waste Discharges to the Environment from Nuclear Power Facilities

Joe E. Logsdon[1]

Data relating to discharges of radioactive liquid and gaseous waste have been compiled for 12 selected operating nuclear power facilities. These data are presented and compared to discharge limits and quantity of electric power produced. In most instances, concentration of radioactivity in waste discharge limits have been maintained at a few percent of the Atomic Energy Commission's licensed discharge limits. Exceptions are mostly associated with either an unusually high percentage of leaky fuel elements or with liquid discharge limits which are artificially low because liquid wastes, in some cases, are not analyzed for radionuclide content.

Comparison of power produced to liquid and gaseous waste discharges showed that boiling water reactors discharge relatively large quantities of gaseous waste and pressurized water reactors discharge relatively high quantities of tritium in liquid waste. No obvious trend is discernible concerning the quantity of radioactive waste discharged as a function of power generation.

Nuclear power plants produce large quantities of radioactive material as byproducts of the operation of the reactor. Most of the radioactive material is contained within the fuel elements and remains there until the fuel is chemically reprocessed at a fuel reprocessing facility. The relatively small portions of radioactive material that escape from the fuel or are produced outside the fuel are contained and processed as radioactive waste at the nuclear power plant. Processing of radioactive waste is geared to decontamination of the waste streams by concentration processes (such as evaporation and demineralization in the case of liquid wastes) with the radioactivity-bearing concentrate shipped offsite for burial at licensed sites. Decontamination is not 100 percent efficient and small amounts of radioactive materials are discharged to the atmosphere and receiving waters. The quantities and types of waste discharged vary from facility to facility depending primarily on design characteristics of the plant and on waste management practices.

Measurements of radioactivity in the environs of nuclear power plants made by State health departments, nuclear power facility operators, and the Environmental Protection Agency (EPA) have, in most cases, revealed little or no increase in environmental radioactivity resulting from plant operations. In those cases where increases were measured, the levels were barely detectable.

This report summarizes the publication, *Radioactive Waste Discharges to the Environment from Nuclear Power Facilities* (*1*) and an addendum to that publication (*2*), excluding the appendices in these reports.

It was determined by routine compliance inspections conducted by the Atomic Energy Commission (AEC) during the first half of 1971, that sampling and analytical methods used at some nuclear power facilities were inappropriate to measure the total activity from all radionuclides in liquid and gaseous effluents. As a result, the AEC required facility operators to resubmit 1970 discharge data that had been included in operating reports. The revised data were published by AEC, Division of Compliance, in a report, *Report on Releases of Radio-*

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[1] Surveillance and Inspection Division, Office of Radiation Programs U.S. Environmental Protection Agency, Washington, D.C. 20406.

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activity from Power Reactors in Effluents During 1970 (*3*). The revised data showed both decreases and increases in quantities discharged. Although there are no significant safety implications in the AEC revised estimates, they show a need for standardization in methods for determining quantities of radioactive material released. This report corrects the 1970 data that appeared in the October 1971 addendum (*2*) to agree with revised estimates published in the AEC report (*3*).

Most of the data in the tables that follow were taken from nuclear facility operating reports and AEC reports. None of the data sources provided statistical error associated with the data and therefore no such indications are included in this report.

Additional information on radionuclides in radioactive wastes from boiling-water reactors is available from a report on a special study by the Bureau of Radiological Health, around the Dresden Nuclear Power Station (*4*). Similar studies have been performed by the EPA, Office of Radiation Programs, around two pressurized water reactors, Yankee (*5*) and Connecticut Yankee. A report of the latter study will be available during the second half of 1972.

Administrative controls

Discharge of radioactive waste to the environment by nuclear power facilities is regulated by the AEC through an operating license issued to the nuclear facility operator. The license requires the licensee to operate the plant in accordance with written Technical Specifications that have been approved by the AEC which include, among other items, limits for radioactive liquid and gaseous discharges. Discharge limits presented in the Technical Specifications are based on maximum permissible concentrations for air and water listed in Appendix B, Table II, 10CFR20 (*6*). These limits take into account the dilution which occurs in the condenser cooling water discharge canal for liquid effluents and in the atmosphere between the point of release and the boundaries of the exclusion area for gaseous effluents. ("Exclusion area" means that area surrounding the reactor in which the licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area.) Discharge limits may further be reduced by the AEC to compensate for possible reconcentration of radionuclides by environmental media. For example, the gaseous discharge limits applied in the licensing process to iodine-131 releases are reduced by a factor of 700 to compensate for possible reconcentration through the pasture-cow-milk exposure pathway.

Sources of liquid and gaseous waste

Radioactivity at nuclear power facilities is produced primarily as a byproduct of the fission process or from neutron activation of structural material within the pressure vessel and impurities in the primary coolant. A combination of leakage of fission products through the fuel cladding into the primary coolant and activation of materials outside the fuel makes the primary coolant the principal source of liquid and gaseous wastes. However, leakage of primary coolant into other systems and various plant operations cause the sources to be numerous. Typical plant operations which result in liquid or gaseous radioactive waste include:

1. refueling and maintenance,
2. control of primary coolant chemistry,
3. sampling,
4. rejection of noncondensable gases from steam condensers,
5. blowdown of steam generators,
6. expansion water when the plant goes from a cold to a hot operation,
7. decontamination of clothing, components, tools, and surfaces, and
8. regeneration of demineralizer resins.

The activation of impurities in systems other than the primary coolant system has not been a major source of liquid radioactive wastes in light water reactors. However, at the Peach Bottom Nuclear Power Station (a high temperature gas-cooled reactor) the absence of liquid radioactive wastes from the primary coolant system makes the primary shield cooling system the principal source of liquid wastes.

Measurements of concentrations of specific radionuclides present in gaseous and liquid wastes are not generally available from nuclear

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power plants. Normally, facility operators report only gross beta-gamma activity and sometimes tritium activity in liquid wastes. Gaseous waste discharges are generally categorized and reported by facility operators as being either halogens and particulates or activation and noble gases. Some facility operating reports include results of specific radionuclide analyses of primary coolant. However, the relative abundance of radionuclides in the primary coolant may be different than the relative abundance in liquid or gaseous waste effluents. Relative abundance of radionuclides in the primary coolant are functions of:

1. cladding leakage,
2. temperature changes which may cause release of particles that have been attached to the surface of the primary system,
3. use and effectiveness of coolant purification,
4. rate of primary system leakage,
5. chemical additives in the primary coolant,
6. type of coolant, and
7. power history.

Relative abundances of radionuclides in the waste effluents are primary functions of:

1. their abundance in the primary coolant,
2. their respective half-lives,
3. design of the radioactive waste treatment system, and
4. waste treatment practices.

Waste treatment capabilities at selected operating nuclear facilities are summarized in table 1.

Most radionuclides can be classified as either fission products or activation products. Tritium, however, is a special case in that it is produced both from fissioning and from neutron activation. It is also special because it is not affected by methods presently used in processing radioactive wastes. Therefore, the tritium released to the primary coolant or produced in the primary coolant is ultimately discharged to the environment in either liquid or gaseous form. Additional information on environmental tritium contamination from nuclear energy sources is provided in reference (*7*).

Operating experience

Most experience on radioactive waste discharge to date has been with pressurized water reactors (PWR) (*8*) and boiling water reactors (BWR) (*9*). Limited operating experience has been gained from a high temperature gas-cooled reactor (HTGR) through the operation of Peach Bottom-1 (*10*). Table 2 provides general information for facilities included in this report.

Liquid discharges

Quantities of gross beta-gamma activity (exclusive of tritium) discharged annually by each facility are shown in table 3. Operating reports for Dresden-1 did not indicate total amount of

Table 1. Waste-processing capability at operating nuclear power facilities

Reactor	Gaseous waste treatment			Liquid waste treatment
	Design holdup or delay time	Particulate treatment	Iodine treatment	
Pressurized water reactors:				
Shippingport	60 days	None	None	Filtration, evaporation, demineralization, gas scrubbing
Yankee	60 days	None	None	Filtration, evaporation, demineralization
Indian Point-1	120 days	Absolute filters	None	Filtration, evaporation, demineralization, gas stripping
San Onofre	30 days	High efficiency filters	None	Filtration, demineralization, gas stripping
Connecticut Yankee	Variable	Fiberglass filter	None	Evaporation, demineralization
Robert E. Ginna	45 days	Filtration	None	Filtration, evaporation, demineralization, gas stripping
Boiling water reactors:				
Dresden-1	20 minutes	Absolute filters	None	Filtration, evaporation, demineralization
Big Rock Point	30 minutes	Absolute filters	None	Filtration, evaporation, demineralization
Humboldt Bay	18 minute design 40 minute design	Absolute filters	None	Filtration, evaporation, demineralization
La Crosse	20 minutes	None	None	Filtration, evaporation, demineralization
Nine Mile Point	30 minutes	Absolute filters	None	Filtration, demineralization
Oyster Creek	30 minutes	Absolute filters	None	Filtration, evaporation, demineralization
High temperature gas-cooled reactor:				
Peach Bottom-1	Variable	Filtration	Charcoal filters	Demineralization

Table 2. General information for facilities included in this report

Facility	AEC docket number	Power level (11)		Location	Vent or stack height (feet)	Vent or stack exhaust rate (cubic feet per minute)	Condenser water for dilution flow rate (gallons per minute)	Body of water receiving liquid waste
		MWt	MWe net					
Pressurized water reactors:								
Shippingport	None	505	90	Shippingport, Pa.	[a] 26	9,000	114,000	Ohio River
Yankee	50-29	600	175	Rowe, Mass.	150	15,000	138,000	Deerfield River
Indian Point-1	50-3	615	265	Buchanan, N.Y.	400	280,000	300,000	Hudson River
San Onofre	50-206	1,347	430	San Clemente, Calif.	100	40,000	350,000	Pacific Ocean
Connecticut Yankee	50-213	1,825	573	Haddam Neck, Conn.	175	70,000	372,000	Connecticut River
Robert E. Ginna	50-244	1,300	420	Rochester, N.Y.	150	([b])	334,000	Lake Ontario
Boiling water reactors:								
Dresden-1	50-10	700	200	Morris, Ill.	300	45,000	166,000	Illinois River
Big Rock Point	50-155	240	71	Charlevoix, Mich.	240	30,000	50,000	Lake Michigan
Humboldt Bay	50-133	240	68	Eureka, Calif.	250	12,000	[c] 100,000	Humboldt Bay
La Crosse	115-5	165	50	Genoa, Wis.	350	70,000	[d] 240,000	Mississippi River
Nine Mile Point	50-220	1,538	500	Oswego, N.Y.	350	216,000	600,000	Lake Ontario
Oyster Creek	50-219	1,690	560	Toms River, N.J.	99	([b])	640,000	Atlantic Ocean
High temperature gas-cooled reactor:								
Peach Bottom-1	50-171	115	40	Peach Bottom, Pa.	150	20,000	43,000	Susquehanna River

[a] Gas discharge stack; vapor container exhaust stack 116 feet.
[b] Information not available.
[c] Flow rate for Humboldt Bay Unit 3 is 51,800 gallons per minute. All calculations are based on a flow rate of 100,000 gallons per minute which is the combined rate for Humboldt Bay Units 1, 2, and 3. Units 1 and 2 are fossil fuel plants.
[d] Includes 180,000 gallons per minute from the Genoa #3 fossil station, which is connected to the La Crosse boiling water reactor outfall.

radioactivity discharged, but gave an average contribution to the radioactivity in the condenser cooling water discharge canal. Except as noted in the table, the total annual discharge for Dresden was obtained by multiplying the facility's contribution to the concentration of radioactivity in the condenser cooling discharge canal times the annual flow rate of the canal as calculated from table 2.

The data in table 3 indicate a general increase in quantities of radioactivity discharged in liquid wastes since 1968 for most of the facilities operating in that year. Exceptions include Shippingport, the Indian Point Station, Big Rock Point, and the Humboldt Bay Power Plant Unit 3. Waste treatment practices are major factors in determining the quantity of radioactivity in liquid wastes available for discharge. Therefore, the reasons for reductions or increases in discharge quantities are generally not discernible from a review of the operating reports. However, the Indian Point Station was shut down for maintenance during most of 1970. This could have contributed to a reduction in discharge quantities.

Calculations have been made based on the data in tables 2 and 3 and the liquid discharge limits for each facility to provide comparisons to discharge limits. These comparisons are provided in table 4. These data do not include tritium which is presented later.

With the exception of Shippingport,[2] discharge limits are prescribed by Technical Specifications. All Technical Specifications limit concentrations in liquid effluents to those listed in Appendix B, Table II of 10CFR20. Without analysis of specific radionuclides, the annual average limit is considered to be 10^{-7} μCi/ml. If liquid wastes are analyzed for specific radionuclides, discharge limits can be based on the maximum permissible concentration for the radionuclides present. These limits normally are less restrictive than the limit for unidentified radionuclides. Most nuclear power plants discharge sufficiently small quantities of radioactivity in liquid wastes that dilution factors associated with the condenser cooling canal are sufficient to permit discharge on the basis of unidentified radionuclides. In most cases, there is no requirement for reporting radionuclide analyses of wastes in operating reports and as a result they are not normally reported. There-

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[2] Shippingport has been developed and operated under AEC sponsorship. Shippingport radioactivity discharge limits are equal to or less than radiation protection standards set forth in Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524 and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Table 3. Total annual liquid waste discharged [a]

Facility	Gross beta-gamma exclusive of tritium (curies)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport[c]	0.083	0.21	0.129	0.09	0.19	0.53	0.14	0.06	0.07	0.08	0.208	0.07
Yankee			.008	.008	.003	.002	.029	.036	.055	.008	.019	.034
Indian Point-1				.130	.164	13.0	26.3	[d]43.7	[e]28.0	[f]34.6	[f]28.0	7.8
San Onofre									.32	1.6	8.0	7.6
Connecticut Yankee									.216	3.9	12.8	6.7
Robert E. Ginna											.017	10
Boiling water reactors:												
Dresden-1		.770	2.095	2.61	2.78	3.82	8.7	11.5	[e]4.3	6.1	[f]9.5	8.2
Big Rock Point[g]				.2	.63	6.22	2.80	6.12	10.1	7.9	11.81	4.7
Humboldt Bay					.397	.664	1.89	2.34	3.13	3.2	1.5	2.4
La Crosse											[f]8.7	6.4
Nine Mile Point											[f].9	28
Oyster Creek											[f].48	18.5
High temperature gas-cooled reactor:												
Peach Bottom-1									.0017	.0004	.000185	.006

[a] Based on operators' reports except as noted.
[b] Data taken from reference (3).
[c] Data taken from *Radiological Health Data and Reports* (12).
[d] Data taken from correspondence dated 2/6/70 from Mr. Donald J. McCormick, Consolidated Edison Co. of New York, Inc., to Mr. J. E. Logsdon, Division of Environmental Radiation, USPHS.
[e] Data taken from reference (13).
[f] Data taken from reference (14).
[g] Data taken from correspondence dated 1/29/70 from Mr. Donald J. McCormick, Consolidated Edison Company of New York, Inc., to Mr. J. E. Logsdon, Division of Environmental Radiation, USPHS.

Table 4. Annual average liquid radioactive-waste discharge concentrations expressed as percent of limit [a]

Facility	Beta gamma radioactivity exclusive of tritium (Percent of discharge limit)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport	0.37	0.93	0.57	0.40	0.84	2.34	0.62	0.27	0.31	0.35	0.91	0.31
Yankee			.03	.03	.01	.007	.1	.13	[c].02	.03	.07	.14
Indian Point-1				.22	.26	22.0	43.0	70.1	[d]1.55	[e]1.65	[f]1.5	.28
San Onofre									.46	3.1	12.8	12
Connecticut Yankee									[d].01	5.35	[g]1.4	2.8
Robert E. Ginna											[h].11	5.0
Boiling water reactors:												
Dresden-1		2.33	6.34	7.9	8.42	11.6	26.4	34.8	13.0	18.5	22.5	25
Big Rock Point				4.46	14.2	54.4	42.4	62.5	[i]50.4	[k]82.3	[m]5.5	3.1
Humboldt Bay					2.77	3.37	9.52	12.15	16.89	19.7	8.7	15
La Crosse											.11	.067
Nine Mile Point												21
Oyster Creek												71
High temperature gas-cooled reactor:												
Peach Bottom-1									.02	.005	.002	.15

[a] Percent of limit calculations were based on the following: (1) 10CFR20 limit for unidentified radionuclides in water of 10^{-7} μCi/ml except as noted, (2) average flow rates in the discharge canals equal to those given in table 2.
[b] Data taken from reference (3).
[c] Concentration limit 10×10^{-7} μCi/ml, based on radionuclide analysis.
[d] Concentration limit 30×10^{-7} μCi/ml, based on radionuclide analysis.
[e] Concentration limit 35×10^{-7} μCi/ml, based on radionuclide analysis.
[f] Concentration limit 27×10^{-7} μCi/ml, based on radionuclide analysis.
[g] Concentration limit 12×10^{-7} μCi/ml, based on radionuclide analysis.
[h] Concentration limit 3×10^{-7} μCi/ml, based on radionuclide analysis.
[i] Concentration limit 2×10^{-7} μCi/ml, based on radionuclide analysis.
[k] Concentration limit 1.5×10^{-7} μCi/ml, based on radionuclide analysis.
[m] Concentration limit 22×10^{-7} μCi/ml, based on radionuclide analysis.

Table 5. Comparison of radioactive-waste discharges to electrical power generation

Facility and reactor	Period covered	Total waste discharges during period			Total gross electrical generation (MWe-h)	μCi discharges/MWe-h gross		
		Liquid		Gaseous		Liquid		Gaseous
		Gross beta-gamma[a] (curies)	Tritium (curies)	Gross beta-gamma (curies)		Gross beta-gamma exclusive of tritium	Tritium	Gross beta-gamma
Pressurized water reactors:								
Shippingport	1959–68	1.6	281	0.58	3.5×10^6	0.46	80	0.17
	1968	.08	35.2	.001	4.1×10^5	.20	86	.002
	1969	.21	20	7.5×10^{-5}	3.4×10^5	.61	59	2.2×10^{-5}
	1970	.071	1.71	1.9×10^{-5}	3.9×10^5	.18	4.4	5×10^{-5}
Yankee	1961–68	.15	[c]6,080	37	8.9×10^6	.02	[c]1,220	4.16
	1968	.008	1,170	.68	1.2×10^6	.007	950	.57
	1969	.019	1,225	4.14	1.2×10^6	.016	1,020	3.45
	1970[b]	.034	1,500	17	1.3×10^6	.009	385	4.4
Indian Point-1	1964–68	112	[d]1,080	166	6.2×10^6	17.1	[d]319	26.77
	1968	34.6	787	59.6	1.6×10^6	21.6	492	37.2
	1969	28	1,100	600	1.8×10^6	15.5	611	333
	1970[b]	7.8	410	1.8×10^3	(e)			
San Onofre	1967–68	1.92		8.8	1.7×10^6	1.1		5.18
	1968	1.6	2,350	4.83	1.4×10^6	1.1	1,680	3.45
	1969	8.0	3,531	256	2.8×10^6	2.86	1,260	91.5
	1970[b]	7.6	4,800	4.2×10^3	3.2×10^6	2.4	1,500	,310
Connecticut Yankee	1967–68	4.1	1,960	3.75	3.7×10^6	1.1	530	1.01
	1968	3.9	1,740	3.74	3.2×10^6	1.3	544	1.17
	1969	12.8	5,100	190	3.8×10^6	3.4	1,342	50
	1970[b]	6.7	7,400	700	3.7×10^6	1.8	2,000	189
Robert E. Ginna	1969	.017	1.26	0	1.5×10^5	.11	8.4	0
	1970[b]	10	110	1×10^4	2.3×10^6	4.3	47.8	4.35×10^3
Boiling water reactors:								
Dresden-1	1961–68	41.9		2.8×10^6	7.6×10^6	5.5		3.68×10^5
	1968	[illegible].1	2.9	2.4×10^5	9.7×10^5	6.3	3	2.47×10^5
	1969	9.5	6	8.6×10^5	8.7×10^5	11	6.9	9.9×10^5
	1970[b]	8.2	5	9.1×10^5	1.4×10^6	5.86	3.57	6.5×10^5
Big Rock Point	1962–68	33.1		1.33×10^6	1.7×10^6	19.5		7.82×10^5
	1968	7.5	[f]34	2.32×10^5	4.5×10^5	17.6	76	5.16×10^5
	1969	11.8	28	2.0×10^5	4.2×10^5	28.1	67	4.8×10^5
	1970[b]	4.7	54	2.8×10^5	4.0×10^5	11.8	135	7.0×10^5
Humboldt Bay[g]	1963–68	11.4	<248	2.23×10^6	1.8×10^6	6.3	<138	1.24×10^6
	1968	3.20	<6.6	8.53×10^5	4.7×10^5	6.9	15	1.83×10^6
	1969	1.5	<5	4.9×10^5	3.9×10^5	3.85	<13	1.0×10^6
	1970[b]	2.4	<7	5.4×10^5	4.3×10^5	5.58	<16	1.3×10^6
La Crosse	1969	8.7		480	7.7×10^4	.01		6.3×10^3
	1970[b]	6.4	20	950	1.3×10^5	49.2	154	7.3×10^3
Nine Mile Point	1969	.897		55	7.1×10^4	.001		7.8×10^2
	1970[b]	28	20	9.5×10^3	1.9×10^6	14.7	10.5	5.0×10^3
Oyster Creek	1969	.481	5.066	7.0×10^3	3.5×10^5	1.37	14.5	2.0×10^4
	1970[b]	18.5	22	1.1×10^5	3.6×10^6	5.1	6.1	3.1×10^4
High temperature gas-cooled reactor:								
Peach Bottom-1	1967–68	.002		117	3.1×10^5	.006		3[illegible]
	1968	.0004		109	1.5×10^5	.003		72[illegible]
	1969	.0002	40	71.5	1.5×10^5	.001	267	476
	1970[b]	.006	<50	5.7	(e)			

[a] Exclusive of tritium.
[b] Data taken from reference (3).
[c] Based on data for 1965–68 wherein electrical generation was 4.98×10^6 MWe-h.
[d] Based on data for 1967–68 wherein electrical generation was 3.39×10^6 MWe-h.
[e] Down for repairs.
[f] Based on an upper limit calculation wherein all liquid waste released during 1968 was assumed to contain as much tritium as was in primary system water.
[g] Data from Pacific Gas and Electric records.

fore, the limit for unidentified radionuclides has been used as the basis for comparison in table 4 except as noted.

The percentages expressed in table 4, in most cases, do not represent a true figure. This is because the discharge limit is a function of the concentration of individual radionuclides present in the waste, and the limit becomes more restrictive with less analysis for specific radionuclides. Therefore, the percentages expressed in table 4 generally can be considered as representing less-than quantities.

The data in table 5 show the ratio of gross beta-gamma radioactivity or tritium discharged to power produced for each facility. Comparison of 1969 and 1970 data on quantities of gross beta-gamma radioactivity in liquid waste discharged per unit of power generation shows a decrease for most PWR's and an increase for most BWR's. However, the facilities that show increased ratios are, with the exception of Humboldt Bay, new facilities.

Gaseous waste discharges per unit of power produced showed a factor of 40 decrease at Shippingport from 1968 to 1970, and a factor of nine increase from 1968 to 1969 at Indian Point. The Indian Point facility was shut down during most of 1970 for maintenance, as mentioned. Some of these repairs (e.g., steam generator tube repairs) should result in reduced quantities of gaseous waste available for discharge in the future. Gaseous discharges per unit of power produced from San Onofre and Connecticut Yankee increased by factors of 370 and 175, respectively, from 1968 to 1970. Reasons for these increases were not explained in the operating reports. Gaseous discharges per unit of power produced at other facilities showed no particular trends.

Figure 1 compares annual discharges of radioactivity in liquid wastes to power generation for facilities included in this report. This figure indicates that both electrical generation and liquid waste discharges are increasing with time, but that radioactivity in liquid waste discharges is not increasing as rapidly as electrical generation.

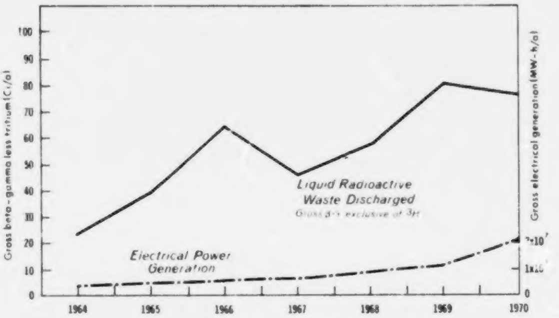

Figure 1. Comparison of annual liquid radioactive waste discharged from all facilities to annual electrical power generation

The ratio of curies of tritium discharged in liquid waste to electrical power produced shows that PWR's, using soluable boron in the primary coolant, discharge relatively higher quantities than BWR's and HTGR's. Higher tritium concentrations in PWR's are due in part to neutron reactions with boron which is added in the form of boric acid to the primary coolant. Since the boron is in solution with the primary coolant, there is no cladding barrier to retain the tritium so produced. This is not the case with a BWR where the boron is used

Table 6. Total annual liquid tritium discharges [a]

Facility	Liquid tritium discharge (curies)												
	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:													
Shippingport[c]	50.0	64.0	99.0	13.2	1.33	2.17	1.39	3.04	27.3	34.8	35.2	20.0	1.71
Yankee[d]				—	—	—	—	1,300	1,920	1,690	1,170	1,230	1,500
Indian Point-1					—	—	—	—	[e]125	[e]297	[e]787	[f]1,100	410
San Onofre										—	2,353	3,530	4,800
Connecticut Yankee										221	1,740	5,100	7,400
Robert E. Ginna												1.26	110
Boiling water reactors:													
Dresden-1			—	—	—	—	—	—	—	—	[e]2.9	[f]6.0	5
Big Rock Point					—	—	—	—	—	—	[g]34	[f]28	54
Humboldt Bay						[h]214	[h]100	[h]54	[h]60	[h]166	[h]6.6	[f]<5	<7
La Crosse													20
Nine Mile Point													20
Oyster Creek												5.066	22
High temperature gas-cooled reactor:													
Peach Bottom-1										—	[i]	[f]40	<50

[a] Data taken from facility operating reports except as noted.
[b] Data taken from reference (3).
[c] Data for years 1958 through 1960 taken from *Shippingpor Operations from Power Operations after First Refueling to Second Refueling (May 1960 to August 16, 1961)* DLCS 36402; data for years 1961 through 1969 taken from *Radiological Health Data and Reports (12)*.
[d] Data taken from *Yankee Nuclear Power Station Operation Report(s)*; tritium analysis was not included in the operating reports prior to 1965.
[e] Data taken from reference (13).
[f] Data taken from reference (14).
[g] Based on an upper limit calculation wherein all liquid waste released during 1968 was assumed to contain as much tritium as was in primary-system water.
[h] Data taken from Pacific Gas and Electric records.
[i] Negligible.
— data not available.

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Table 7. Tritium discharges in liquid wastes compared to AEC limits [a]

	Average discharge[b] concentration (μCi/ml)			Percent of limit		
	1968	1969	1970[c]	1968	1969	1970[c]
Pressurized water reactors:						
Shippingport	1.6×10^{-7}	8.8×10^{-8}	7.5×10^{-9}	0.0053	0.003	0.0002
Yankee	4.5×10^{-6}	4.4×10^{-6}	5.5×10^{-6}	.15	.15	.18
Indian Point-1	1.6×10^{-6}	1.8×10^{-6}	6.9×10^{-7}	.045	.06	.02
San Onofre	5.0×10^{-6}	$5\ \ \times10^{-6}$	6.9×10^{-6}	.17	.17	.23
Connecticut Yankee	2.4×10^{-6}	6.8×10^{-6}	1.0×10^{-5}	.08	.23	.33
Robert E. Ginna		1.9×10^{-9}	1.7×10^{-7}		.00006	.005
Boiling water reactors:						
Dresden-1	$9\ \ \times10^{-9}$	1.8×10^{-8}	1.5×10^{-8}	.0003	.0006	.0005
Big Rock Point	3.6×10^{-7}	2.8×10^{-7}	5.4×10^{-7}	.012	.01	.02
Humboldt Bay	$<4.0\times10^{-8}$	$<2.5\times10^{-8}$	$<3.5\times10^{-8}$	<.0014	<.001	<.001
La Crosse			4.2×10^{-8}			.001
Nine Mile Point			1.7×10^{-8}			.0006
Oyster Creek		4.3×10^{-8}	1.7×10^{-8}		.001	.0006
Gas cooled reactors:						
Peach Bottom-1	Negligible	4.6×10^{-7}	<[illegible].3×10^{-7}	Negligible	.015	<.02

[a] Based on 10CFR20 limit for unrestricted areas of 3×10^{-3} μCi/cc and dilution in the condenser cooling water discharge canal.

[b] Calculation based on annual quantity of tritium discharged and the condenser cooling water flow rate.

[c] Data taken from reference (*3*)

in the form of cladded plates or curtains. Other sources of tritium which are common to both PWR's and BWR's include fission product tritium and reactions of neutrons with lithium-7 nitrogen, helium-3, poison material used in control rods or plates, and reactions with structural material.

Discharges of tritium in liquid wastes are generally reported separately from gross beta-gamma discharges primarily because of tritium's high relative abundance in liquid wastes and relatively high discharge concentration limit as compared to the concentration limit for unidentified radionuclides. Data in table 6 indicate that the quantity of tritium in liquid waste is high relative to the quantity of other radionuclides. However, the relative hazard per curie of tritium is low. The data in table 6 are expanded in table 7 to show derived average discharge concentrations and percent of the discharge limit for 1968. Comparing the data in tables 4 and 7, it is evident that concentrations of gross beta-gamma activity (exclusive of tritium) in liquid discharges more nearly approach the limit than do concentrations of tritium. This is significant because current methods for treatment of liquid wastes are ineffective in reducing quantities of tritium discharged.

Gaseous wastes

Gaseous wastes may include particulates, volatiles (such as iodine), or gases. The gases constitute the major portion of discharged radioactivity via the stack and are generally referred to as activation and noble gases.

Technical Specifications limit average discharge rates for radioactive gaseous wastes such that the average annual concentrations at the plant's exclusion boundary will not exceed those listed in Appendix B, Table II of 10CFR20. Additional limits (usually a factor of ten higher than limits for average release rates) are established for maximum release rates. Limits for gaseous release rates are a function of the atmospheric dilution available between the point of release and the exclusion boundary. Since atmospheric dilution factors are affected by stack height, distance from stack to exclusion boundary, topography and local meteorology, gaseous discharge limits vary widely from facility to facility. Limits for gaseous releases are usually expressed in μCi/s with limits for iodines and particulates being relatively more restrictive than the limits for activation and noble gases. The reason for the more restrictive limits for iodines and particulates is their potential for reconcentration through environmental media. For example, the discharge limit for iodine-131 is generally set at a factor of 700 below the rate that would produce the 10CFR20 concentration limit of 1×10^{-10} μCi/ml at the exclusion boundary. This is to compensate for possible reconcentration through the pasture-cow-milk chain. The isotopic mixtures of noble gas discharges are such that the maximum permissible concentration in the environment as calculated from values listed in 10CFR20 range from 3×10^{-8} μCi/ml with decay of less than 2 hours to 3×10^{-7} μCi/ml at ages of 3 days and longer (*15*). The increase in concentration limits with increased decay time is due to the decay of the short-lived radionuclides which have relatively lower concentration limits.

Table 8 provides an annual summary of discharges of activation and noble gases. With the exception of Humboldt Bay, the facilities included in this report do not include separate discharge rates of halogens and particulates in their operating reports. However, these data have been reported by the AEC in reference (*13*) for 1967 through 1970 and are reproduced in table 9 along with the percent of discharge limit for each facility.

Table 10 provides a summary of annual average discharge rates for activation and noble gases expressed as percent of discharge limits. Unlike other facilities, the discharge limit for Shippingport does not take into consideration atmospheric dilution between the point of discharge and the exclusion boundary. The discharge limit for Shippingport is 3×10^{-7} μCi/ml in the stack. The derivation of the discharge limit (1.26 μCi/s), used in table 10 for calculating percent of limit, is based on a stack discharge rate of 9,000 cubic feet per minute.

Review of the annual discharge rate for each of the facilities listed in table 8 reveals that boiling water reactors discharge very much larger quantities of activation and noble gases than pressurized water reactors. This trend is further verified in table 5 where the ratio of gaseous waste discharged to electrical power produced is presented. The greater quantities of radioactive gases discharged from BWR's are a result of the shorter holdup for decay prior to discharge to the environment. Gases in the primary coolant system of a BWR are carried over with the steam to the condenser air ejectors where they are immediately ejected as noncondensables and discharged to the environment with a holdup time of 20–30 minutes. The radioactive gases generated in a PWR are retained for longer periods in the primary coolant system. Those that are released from the coolant system are stored in tanks for further decay prior to discharge and therefore PWR's discharge less short-lived gaseous wastes to the atmosphere. As a result, population exposure to external radiation from gaseous releases will be higher in the immediate vicinity of a BWR than in the immediate vicinity of a PWR. However, since the increased quantities discharged from a BWR are made up of short-lived radionuclides, the contribution by BWR's to general population exposures should not be greater than for other types of reactors.

Figures 2 and 3 provide plots of electrical generation and gaseous waste discharges as a function of time. The graphs have been separated into BWR's and PWR's. Since gaseous waste discharges at Indian Point-1 have been much higher than at other PWR's, its data were not included. These figures show relationships for each year, but there is not enough history to establish definite trends. Several facilities have been involved in research programs utilizing the reactor to test different fuels and cladding, in some cases resulting in significant releases of fission products from the fuel elements to the primary coolant. Humboldt Bay has experienced a high percentage of leaking fuel cladding resulting in relatively large amounts of fission products being released to the primary coolant. Such releases affect the shapes of the discharge curves in figures 2 and

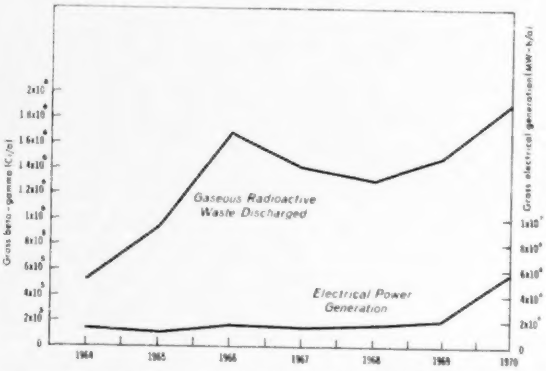

Figure 2. Comparison of annual gaseous radioactive waste discharged to annual electrical power generation for all BWR facilities in table 5

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Table 8. Total annual gaseous waste discharged [a]

Facility	Noble and activation gases (curies)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport[c]	0.014	0.029	0.103	0.012	0.351	0.0024	0.032	0.030	0.002	0.001	0.000075	0.000019
Yankee			.00096	21.7	7.4	.95	1.7	2.4	2.3	.68	4.14	17
Indian Point-1				—	.0072	13.2	33.1	35.4	23.4	59.7	[d]600	1,800
San Onofre									4.02	4.83	256	4,200
Connecticut Yankee									.021	3.74	[d]190	700
Robert E. Ginna											0	10,000
Boiling water reactors:												
Dresden-1[e]			34,800	284,000	71,600	521,000	610,000	736,000	[f]260,000	240,000	862,300	910,000
Big Rock Point[g]				25.6	803	783	132,000	705,000	264,000	232,000	200,000	280,000
Humboldt Bay[h]					716	5,975	197,000	282,000	896,000	853,000	492,000	540,000
La Crosse											480	950
Nine Mile Point											55	9,500
Oyster Creek											7,000	110,000
High temperature gas-cooled reactor:												
Peach Bottom-1								.00126	7.76	109	71.5	5.7

[a] Based on operators' reports except as noted.

[b] Data taken from reference (*3*).

[c] Data taken from *Radiological Health Data and Reports* (*12*). Data corrected from 1963 and 1964 taken from correspondence dated 3/10/70 from the Naval Reactors Branch, U.S. Atomic Energy Commission, to Mr. C. L. Weaver, Division of Environmental Radiation, Bureau of Radiological Health.

[d] Data taken from reference (*14*).

[e] Data from 1961 and 1962 based on maximum rate of noble fission gas activity discharged; data from 1963–1968 based on average activity discharge rate for the year while plant was operating.

[f] Data taken from reference (*13*).

[g] Data taken from correspondence dated 3/10/70 from the Naval Reactors Branch, U.S. Atomic Energy Commission, to Mr. C. L. Weaver, Division of Environmental Radiation, Bureau of Radiological Health.

[h] Data taken from Pacific Gas and Electric records.

—, plant was operational but discharge data were not available.

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Table 9. Releases of halogens and particulates from power reactors in gaseous effluents

Facility	Permissible[a] (curies)	1967		1968		1969		1970[b]	
		Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release
Pressurized water reactors:									
Yankee	0.03	Negligible	<1	Negligible	<1	<0.0001	0.01	(c)	
Indian Point	7.6	Negligible	<1	Negligible	<1	.025	.33	.075	1
San Onofre	.8	Negligible	<1	Negligible	<1	<.0001	<.001	<.0001	<.001
Connecticut Yankee	.27	0.001	.5	Negligible	<1	.001	.37	.0015	.7
Robert E. Ginna	1.7					<.0001	<.001	.05	3
Boiling water reactors:									
Dresden-1	85.0	.039	.04	0.15	.15	.30	.35	3.3	4.3
Big Rock Point	38.0	.25	.66	.09	.24	.2	.53	.13	.35
Humboldt Bay	5.6	.64	11	.45	8	.65	12.0	.35	6.2
La Crosse	1.6					<.063	<4.0	<.063	<4
Nine Mile Point	63.0					<.001	<.001	<.06	<.1
Oyster Creek	126.0					.003	.002	.32	.25
High temperature gas cooled reactors:									
Peach Bottom-1	.12	Negligible	<1	Negligible	<1	<.0006	<.5	<.0006	<.6

[a] Where the Technical Specifications do not state an annual limit for the iodines and particulates, an MPC value of 1×10^{-10} µCi/cc was used. This MPC is based on the most restrictive isotope normally found—iodine-131. The annual limit was reduced by a factor of 700 to account for reconcentration.

[b] Data taken from reference (*3*).

[c] Not measured.

Table 10. Annual gaseous radioactive waste discharges

Facility	Noble and activation gases (percent of limit)[a]											
	1959	1960	1961	1962	1963	1964	1965	1966	1967[b]	1968[b]	1969[c]	1970[d]
Pressurized water reactors:												
Shippingport	0.035	0.073	0.26	0.03	0.87	0.006	0.08	0.075	0.005	0.0025	<0.001	<0.001
Yankee			.000014	.32	.11	.014	.025	.035	.036	.008	.063	.26
Indian Point-1					4.5×10^{-7}	.00083	.0020	.0022	.0015	.0037	.01	.03
San Onofre									.0024	.0003	.014	.75
Connecticut Yankee									[illegible]	.0039	1.0	.24
Robert E. Ginna											0	2.8
Boiling water reactors:												
Dresden-1			.158	1.29	.32	2.37	2.77	3.34	.87	1.09	3.91	5.2
Big Rock Point						.0025	.43	2.27	.85	.74	.65	.88
Humboldt Bay					.045	.38	12.5	17.8	56.7	54.0	31.2	34
La Crosse											.1	.3
Nine Mile Point											<.001	.037
Oyster Creek											.075	1.2
High temperature gas-cooled reactor:												
Peach Bottom-1								$6.67\times10^{-[illegible]}$	.04	.087	.38	.003

[a] Percent of limit calculations were based on the following: (1) values as given in table 2 for stack flow rates and table 8 for annual quantities discharged, (2) discharge limits presented in references (*5*) and (*2*) except as noted. In cases where the discharge limit is expressed as a factor times MPC and no MPC is given, then 3×10^{-7} μCi/cc is used.

[b] Limits for 1967 and 1968 from reference (*13*) except for Shippingport. Shippingport limits from reference (*16*) through 1969.

[c] Limits for 1969 based on reference (*14*).

[d] Data taken from reference (*3*).

3 and therefore reduce their significance for establishing trends.

Table 11 has been added to provide an indication of the radionuclides present in liquid and gaseous discharges. Most facilities do not routinely report discharges by individual radionuclide. Review of data in table 11 also shows that the facilities which do report radionuclide data have no consistent format. These situations should be corrected upon promulgation of guides currently proposed by AEC.

Table 11. Radionuclides reported in waste discharges, 1970 [a]

Radionuclides	Humboldt Bay (BWR) (curies)	Connecticut Yankee (PWR) (curies)	Big Rock Point (BWR)	Nine Mile Point (BWR)	La Crosse (BWR)
Gaseous:					
Xenon-133	[b]6,420	603		160 μCi/s	
Xenon-133m	[b]535				
Xenon-135	[b]64,700	[c]84.6		165 μCi/s	
Xenon-135m	82,900				
Xenon-137	4,280				
Xenon-138	217,000			75 μCi/s	
Krypton-83m	13,400				
Krypton-85		[c]9.76			
Krypton-85m	[b]16,600			38 μCi/s	
Krypton-87	[b]73,300			130 μCi/s	
Krypton-88	[b]55,100			110 μCi/s	
Krypton-89	535				
Nitrogen-13				<10 μCi/s	(d)
Argon-41		[c]2.7			
Liquids:					
Chromium-51				60.0 percent	
Manganese-54	.24			5.9 percent	
Cobalt-58		3.94		15.2 percent	(d)
Cobalt-60	.84	.013		9.5 percent	(d)
Zinc-65	.12		42% of total		
Iron-59				9.0 percent	
Iodine-131	.09	.25	(e)	.4 percent	
Cesium-137	.84	.10	(e)		
Cesium-134	.24		(e)		
Strontium-89	[f].01				
Strontium-90	[f].01				

[a] Includes only facilities which reported data on specific radionuclides other than tritium.

[b] These six nuclides are directly measured, the other gaseous nuclides are calculated.

[c] Expressed as xenon-133 equivalent.

[d] Reported as being present but without specific quantities.

[e] Activity was 42 percent zinc-65. The remaining portion was mainly cesium-134, cesium-137, and iodine-131.

[f] Reported by the facility as a conservative estimate.

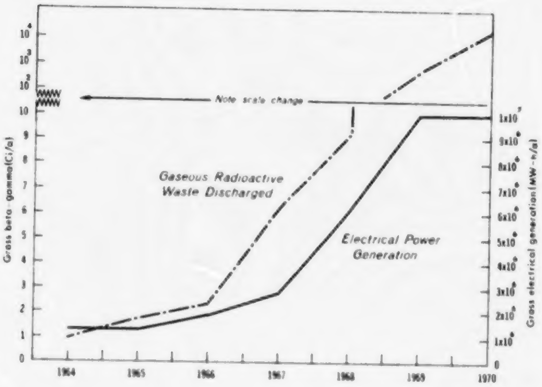

Figure 3. Comparison of annual gaseous radioactive waste discharged to electrical power generation for all PWR facilities except Indian Point Station, Unit 1

Summary

Data pertaining to discharges of radioactive liquid and gaseous wastes from 12 selected operating nuclear power facilities have been presented and discussed. The following summary is based on these data:

1. Experience to date with nuclear power plants has shown that careful waste management practices, engineered safeguards, and proper operating procedures generally result in radioactivity levels in waste effluents of a few percent or less of the AEC's licensed discharge limits. Exceptions are mostly associated with either an unusually high percentage of leaky fuel elements or with liquid discharge limits which are artificially restrictive as a result of not analyzing liquid wastes for radionuclide content.

2. Technical Specifications for all facilities limit liquid discharges such that average annual concentrations of radioactivity in the condenser cooling discharge canal will be less than values listed in Appendix B, Table II, 10CFR20. The limits for gaseous discharges vary from facility to facility, depending on available dilution factors in the atmosphere. They have varied in the manner in which they are expressed; however, the AEC is in the process of developing uniform reporting requirements. They also have varied in that the limits for halogens and particulates for some of the early reactors did not include the "700" factor to account for possible reconcentration through environmental media.

3. A number of comparisons has been made of power produced versus liquid or gaseous waste discharges. The most predominant trends shown in these comparisons are that boiling water reactors discharge relatively large quantities of gaseous waste and pressurized water reactors discharge relatively high quantities of tritium in liquid wastes. No obvious trend is discernible concerning quantities of waste discharged as a function of power generation. This is to be expected since fuel cladding integrity and waste treatment practices are major factors in determining the quantity of waste available for discharge.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, November 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk (calcium and potassium) have been used as a means for assessing the biological behav-

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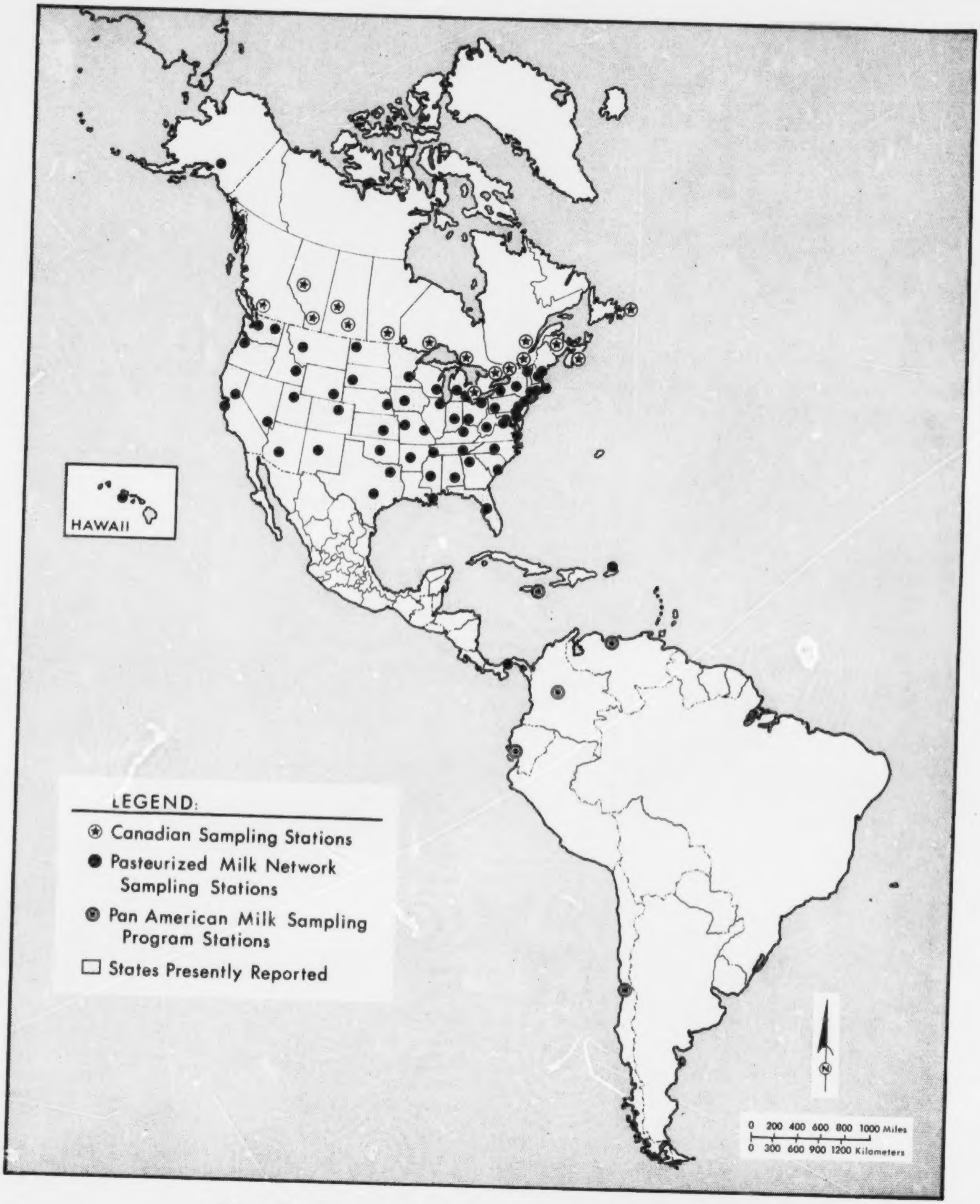
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
N

Figure 1. Milk sampling networks in the Western Hemisphere

ior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of all radionuclides from those of previous studies. Some improvement is still needed on the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

Table 1. Distribution of mean results in milk quality control experiment

Isotope and known concentration $\pm 2\sigma$	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 ± 6 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 ± 6 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 ± 6 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 ± 2.4 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations

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Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period December 1970 through November 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	6	11	11
Alaska:	Palmer[c]	P	3	4	22	12
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	10	12	15	13
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	3	0	0
	Del Norte	P	7	14	0	10
	Fresno	P	0	2	0	3
	Humboldt	P	3	4	0	5
	Los Angeles	P	0	2	0	2
	Mendocino	P	2	6	0	7
	Sacramento	P	2	3	0	3
	San Diego	P	0	1	0	3
	Santa Clara	P	0	1	0	4
	Shasta	P	3	3	11	5
	Sonoma	P	0	3	0	5
Colo:	Denver[c]	P	NA	5	0	7
	East	R	(d)		NS	[e]0
	Northeast	R	(d)		[e]0	[e]1
	Northwest	R	(d)		NS	[e]0
	South Central	R	(d)		[e]0	[e]0
	Southeast	R	(d)		NS	
	Southwest	R	(d)		[e]0	[e]2
	West	R	(d)		NS	[e]0
Conn:	Hartford[c]	P	NA	7	0	9
	Central	P	7	7	13	14
Del:	Wilmington[c]	P	NA	8	0	5
D.C:	Washington[c]	P	NA	8	11	9
Fla:	Tampa[c]	P	7	5	41	44
	Central	R	5	6	34	42
	North	R	7	10	14	23
	Northeast	R	6	7	70	35
	Southeast	R	9	7	44	54
	Tampa Bay area	R	6	6	37	43
	West	R	19	11	18	18
Ga:	Atlanta[c]	P	NA	10	17	15
Hawaii:	Honolulu[c]	P	5	3	0	2
Idaho:	Idaho Falls[c]	P	5	5	0	4
Ill:	Chicago[c]	P	5	6	0	9
Ind:	Indianapolis[c]	P	NA	7	0	5
	Central	P	5	8	10	12
	Northeast	P	4	8	5	14
	Northwest	P	8	9	15	14
	Southeast	P	7	9	10	14
	Southwest	P	8	10	20	14
Iowa:	Des Moines[c]	P	NA	5	14	3
	Iowa City	P	4	7	14	14
	Des Moines	P	5	7	11	12
	Little Cedar	P	NS		NS	
	Spencer	P	8	5	0	10
Kans:	Wichita[c]	P	NA	7	11	2
	Coffeyville	P	7	9	0	15
	Dodge City	P	4	6	12	7
	Falls City, Nebr	R	8	4	0	12
	Hays	P	3	10	10	9
	Kansas City	P	4	9	13	15
	Topeka	P	6	9	0	11
	Wichita	P	8	10	17	12
Ky:	Louisville[c]	P	NA	9	0	4
La:	New Orleans[c]	P	15	14	13	20
Maine:	Portland[c]	P	NA	9	0	19
Md:	Baltimore[c]	P	NA	8	0	6
Mass:	Boston[c]	P	7	8	0	13
Mich:	Detroit[c]	P	NA	7	0	11
	Grand Rapids[c]	P	NA	8	0	10
	Bay City	P	7 (3)	6	10 (3)	16
	Charlevoix	P	10 (4)	10	13 (5)	16
	Detroit	P	8	7	0	8
	Grand Rapids	P	4	6	13	11
	Lansing	P	8 (2)	8	12 (2)	16
	Marquette	P	7 (2)	10	21 (2)	23
	Monroe	P	3	5	0 (2)	4
	South Haven	P	6 (3)	6	7 (4)	9
Minn:	Minneapolis[c]	P	NA	8	15	13
	Bemidji	P	8	9	13	19
	Duluth	P	15	17	25	29
	Fergus Falls	P	9	7	13	14
	Little Falls	P	17	17	21	28
	Mankato	P	6	6	15	12
	Minneapolis	P	13	13	13	17

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period December 1970 through November 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES: continued						
Minn.	Rochester	P	10	8	20	13
	Worthington	P	6	5	0	0
Miss:	Jackson[c]	P	NA	12	0	9
Mo:	Kansas City[c]	P	NA	8	0	6
	St. Louis[c]	P	NA	6	0	5
Mont:	Helena[c]	P	NA	6	18	12
Nebr:	Omaha[c]	P	NA	7	0	4
Nev:	Las Vegas[c]	P	NA	2	0	1
N.H:	Manchester[c]	P	NA	8	11	20
N.J:	Trenton[c]	P	NA	8	0	10
N. Mex:	Albuquerque[c]	P	NA	8	0	0
N.Y:	Buffalo[c]	P	6	7	0	10
	New York City[c]	P	NA	3	13	12
	Syracuse[c]	P	NA	7	0	10
	Albany	P	9	0	[d]0 (3)	[d]0
	Buffalo	P	[d]0	[d]7	[d]0	[d]0
	Massena	P	8	7	[d]0 (2)	20
	New York City	P	6	7	[d]0	[d]0
	Syracuse	P	[d]0	5	[d]0	[d]0
N.C:	Charlotte[c]	P	NA	11	15	12
N. Dak:	Minot[c]	P	NA	9	20	12
Ohio:	Cincinnati[c]	P	NA	7	0	2
	Cleveland[c]	P	NA	7	0	8
Okla:	Oklahoma City[c]	P	NA	6	21	10
Oreg:	Portland[c]	P	4	5	0	7
	Baker	P	NA	3	[d]0	4
	Coos Bay	P	3	4	[d]0	7
	Eugene	P	0	2	[d]0	2
	Medford	P	2	2	[d]0	3
	Portland composite	P	NA	6	NA	6
	Portland local	P	NA	4	NA	10
	Redmond	P	2	3	[d]0	2
	Tillamook	P	NA	5	25	15
Pa:	Philadelphia[c]	P	NA	8	0	8
	Pittsburgh[c]	P	NA	11	0	10
	Dauphin	P	25	8	15	12
	Erie	P	3	6	19	16
	Philadelphia	P	8	8	22	17
	Pittsburgh	P	0	8	9	15
R.I:	Providence[c]	P	NA	8	12	16
S.C:	Charleston[c]	P	9	9	11	14
S. Dak:	Rapid City[c]	P	NA	6	0	5
Tenn:	Chattanooga[c]	P	NA	9	12	10
	Memphis[c]	P	NA	7	0	9
	Chattanooga	P	8	9	12	15
	Clinton	R	9	9	13 (2)	14
	Fayetteville	R	NS	1	NS	11
	Kingston	R	7	7	6 (2)	12
	Knoxville	P	7	7	14	12
	Lawrenceburg	R	6	5	0 (2)	3
	Nashville	P	7	7	0 (2)	10
	Pulaski	R	8	8	0	2
Tex:	Austin[c]	P	NA	1	0	0
	Dallas[c]	P	NS	6	NS	6
	Amarillo	R	NS	3	NS	2
	Corpus Christi	R	6	5	0	0
	El Paso	R	2	3	0	0
	Fort Worth	R	NS	4	NS	0
	Harlingen	R	NS	3	NS	0
	Houston	R	NS	8	NS	11
	Lubbock	R	2	3	0	0
	Midland	R	NS	3	NS	0
	San Antonio	R	NS	4	NS	0
	Texarkana	R	NS		NS	
	Tyler	R	8	13	0	12
	Uvalde	R	NS		NS	
	Wichita Falls	R	6	7	0	4
Utah:	Salt Lake City[c]	P	5	5	0	13
Vt:	Burlington[c]	P	NA	6	0	12
Va:	Norfolk[c]	P	NA	9	0	6
Wash:	Seattle[c]	P	NA	5	12	5
	Spokane[c]	P	NA	6	15	4
	Benton County	R	3	1	0	0
	Franklin County	R	NS	4	NS	0
	Sandpoint, Idaho	R	11	13	20	22
	Skagit County	R	7	8	19	13
W. Va:	Charleston[c]	P	NA	7	0	8
Wisc:	Milwaukee[c]	P	NA	6	0	10
Wyo:	Laramie[c]	P	NA	4	12	12

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period, December 1970 through November 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:						
Alberta:	Calgary	P	NA		18	21
	Edmonton	P	NA		17	24
British Columbia:	Vancouver	P	NA		22	24
Manitoba:	Winnipeg	P	NA		19	23
New Brunswick:	Fredericton	P	NA		22	24
Newfoundland:	St. John's	P	NA		22	31
Nova Scotia:	Halifax	P	NA		23	24
Ontario:	Ottawa	P	NA		32	33
	Sault Ste. Marie	P	NA		20	25
	Thunder Bay	P	NA		16	15
	Toronto	P	NA		17	14
	Windsor	P	NA		4	11
Quebec:	Montreal	P	NA		13	19
	Quebec	P	NA		26	30
Saskatchewan:	Regina	P	NA		16	15
	Saskatoon	P	NA		16	18
CENTRAL AND SOUTH AMERICA:						
Colombia:	Bogota	P	2	2	0	0
Chile:	Santiago	P	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Mandeville	P	4	5	65	80
Venezuela:	Caracas	P	0	0	0	0
Canal Zone:	Cristobal[c]	P	NA	1	11	8
Puerto Rico:	San Juan[c]	P	NA	4	17	12
PMN network average[f]			7	7	6	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

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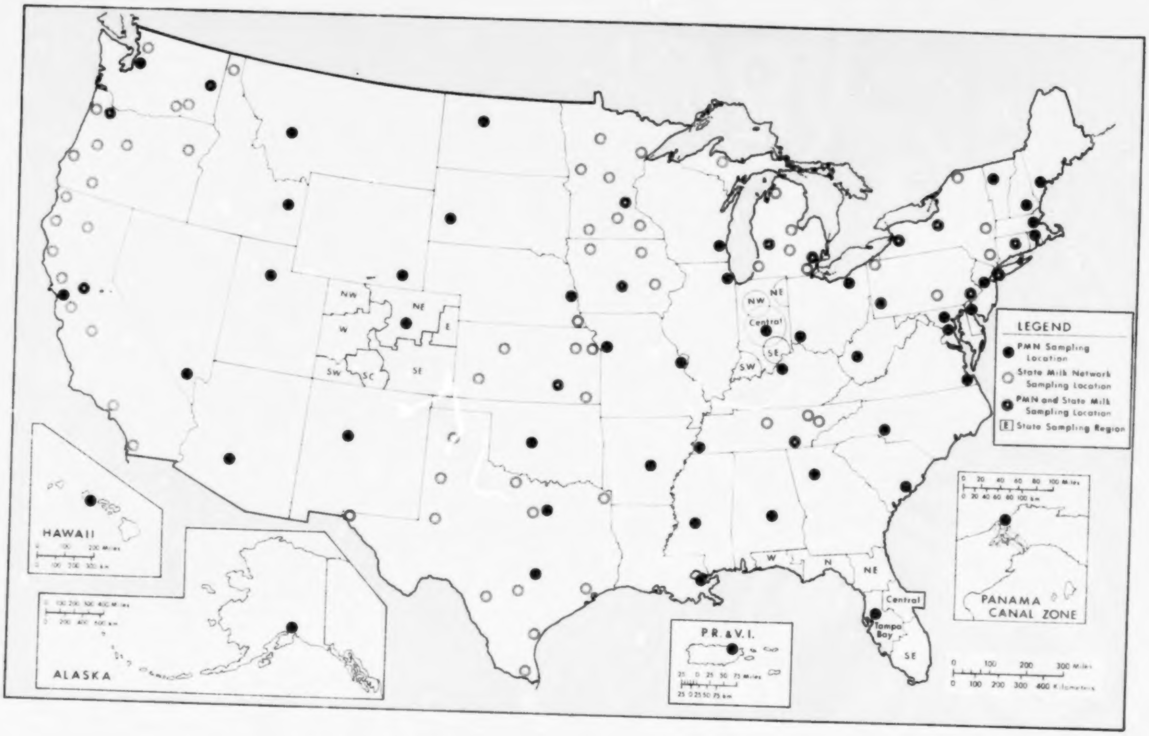
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
E State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for November 1971 and the 12-month period, December 1970 to November 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for November 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, November 1971 [a]

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Alaska:	Palmer (PMN)	7	
Kans:	Hays (State)	5	
Tenn:	Kansas City (State)	6	
	Clinton (State)		6

[a] No iodine-131 was detected.

Strontium-90 monthly averages ranged from 0 to 25 pCi/liter in the United States for November 1971, and the highest 12-month average was 17 pCi/liter (Duluth, Little Falls, Minn. (State)), representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 70 pCi/liter in the United States for November 1971, and the highest 12-month average was 54 pCi/liter (Southeast Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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(*6*) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 in Total Diet and Milk	January–June 1971	December 1971
Connecticut Standard Diet	January–December 1970	December 1971
Institutional Total Diet	April–June 1971	November 1971
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	June 1971	February 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1970	December 1971
Minnesota	January–June 1970	November 1971
North Carolina	January–December 1967	May 1969
New York	July 1969–June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Radiostrontiumin Tap Water, HASL	January–June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April–June 1971	November 1971
Washington	July 1968–June 1969	February 1971

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Gross Radioactivity in Surface Waters of the United States July 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from six rivers during July 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements. Additional water samples for March 1971 that were

Table 1. Gross radioactivity in U.S. surface waters, July 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Big Horn River:					
Hardin, Mont	[a]1	<.2	2	<1	25
Clinch River:					
Kingston, Tenn	[b]2	<.2 (<.2–<.2)	<.2 (<.2–<.2)	2 (1–3)	4 (3–5)
Mississippi River:					
Burlington, Iowa	[a]1	3	1	15	8
Ohio River:					
Cincinnati, Ohio	[b]4	<1.0 (<.2–2)	<4.0 (<.2–5)	3.2 (1–4)	8.3 (7–9)
Roanoke River:					
John Kerr Dam, Va	[b]4	<.2 (<.2–<.2)	<.4 (<.2–1)	<1.6 (<.2–2)	5.8 (5–6)
St. Lawrence River:					
Massena, N.Y	[b]2	<.2 (<.2–<.2)	<1.6 (<.2–3)	3 (3–3)	6 (6–6)

[a] Indicates single monthly grab samples.
[b] Where more than one sample is analyzed during the month, the minimum and maximum values are in parentheses.

Table 2. Gross radioactivity in U.S. surface waters, March 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Arkansas River:					
Ponca City, Okla	[a]1	1	3	6	8
Mississippi River:					
West Memphis, Ark	[a]1	6	1	19	7
Vicksburg, Miss. No. 2	[a]1	8	<.2	25	5
Vicksburg, Miss	[a]1	1	<.2	6	5
Red River:					
Denison, Tex	[a]1	<.2	<.2	<1	7
Index, Ark	[a]1	2	1	9	11
Rio Grande:					
El Paso, Tex	[a]1	6	8	33	39
Laredo, Tex	[a]1	1	5	7	20
Brownsville, Tex	[a]1	<.2	2	2	8
Sabine River:					
Ruliff, Tex	[a]1	1	<.2	4	5
Trinity River:					
Livingston, Tex	[a]1	1	<.2	5	13
Verdigris River:					
Nowata, Okla	[a]1	1	2	6	4

[a] Indicates a composited sample for second quarter ending in March 1971 of the 1971 Water Year.

omitted from the November 1971 issue of *Radiological Health Data and Reports* are shown in table 2.

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Radioactivity in Surface Waters of the Colorado River Basin, Radium Monitoring Network, 1968 [1]

Colorado River Basin Water Quality Control Project
Environmental Protection Agency

The Radium Monitoring Network is a surface water surveillance system currently consisting of 20 sampling stations located throughout the Colorado River Basin (figure 1). The purpose of this network is to provide a continuous assay of basin river water radioactivity resulting primarily from uranium milling and milling industry waste discharges. The analyses for gross alpha, gross beta, thorium alpha, lead-210, polonium-210, and strontium-90 have been performed on samples from selected sampling stations since July 1963.

Sampling procedures

Depending on individual station parameters, Radium Monitoring Network (RMN) samples are collected as either automatic or grab samples. Grab samples are collected once or three times per week and automatic samplers collect 21 milliliter portions every hour. The samples are sent as collected to the Colorado River Basin Water Quality Control Project Laboratory where they are composited, filtered and analyzed for the desired radionuclides.

Radium-226 with the lowest recommended maximum permissible concentration in water of all radionuclides, has been the radioactive contaminant of greatest concern in uranium discharges. Consequently, initial and primary emphasis was placed on the analysis for radium only. In October 1963, uranium determinations were added. Beginning in July 1963, samples from selected stations were combined into quarterly composites for gamma-ray spectroscopy and analyzed for gross alpha, gross beta, strontium-90, thorium alpha, and lead-210 radioactivities. Some determinations for polonium-210 were also performed.

Analytical methods

Water samples are composited and filtered through 0.45 micron-membrane filters as soon as possible after the samples for the compositing period are received. After filtration, samples are acidified with a 2 percent by volume 12 *N* hydrochloric acid and radiochemical determinations are then performed on the filtered water.

Radium-226 is determined by an emanation method (*1*). Lead-210 is determined by an iodine-dithiozone extraction method (*2*). Uranium is determined by a fluorometric method, using a sodium carbonate-potassium carbonate-sodium fluoride flux (*3*). Gross alpha and beta radioactivity determinations are made on dried dissolved solids from the waters, using appropriate correction factors for self-absorption (*4*). Strontium-90 is isolated by coprecipitation with calcium and magnesium carbonate (*5*). It is absorbed in an ion exchange column and the yttrium-90 which grows in is eluted and measured. Polonium-210 is determined by the method described in reference (*6*). Gross gamma-ray determinations are done using a sodium iodide crystal as a detector in combination with a multichannel analyzer and a scaler as the recording device.

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[1] Summarized from "Radium Monitoring Network Data," release numbers 13, 14, and 15.

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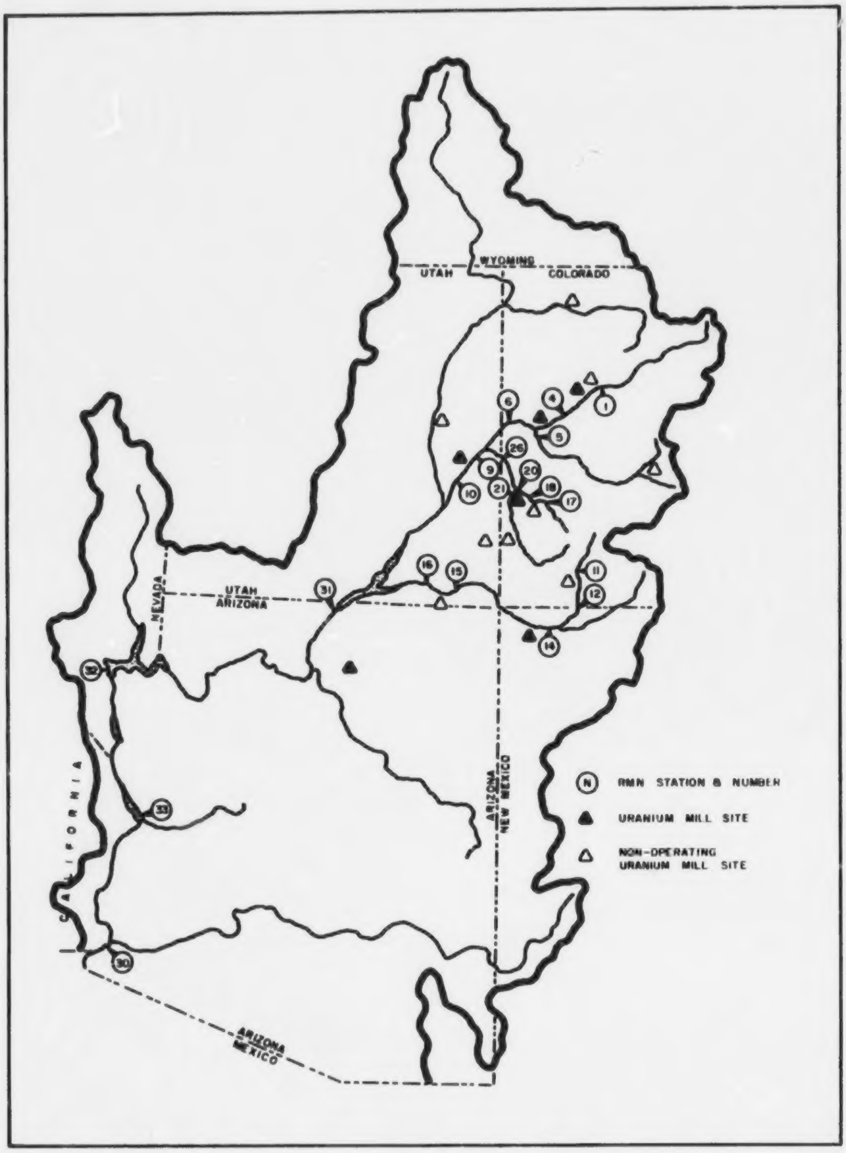
WYOMING
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NEVADA
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CALIFORNIA
33
ARIZONA
NEW MEXICO
30
ARIZONA
MEXICO
N RMN STATION & NUMBER
▲ URANIUM MILL SITE
△ NON-OPERATING URANIUM MILL SITE

Figure 1. Colorado River Basin radium monitoring network

Alpha-particle emitting thorium isotopes are determined by coprecipitation with ferric hydroxide and yttrium fluoride followed by extraction with thenoyltrifluoroacetone, mounting, and alpha-particle counting.

Results

Radium-226 concentrations at all stations except station 20 continue to average well below recommended maximum concentrations. A summary of radium-226 and uranium determina-

Table 1. Radium-226 in surface waters of the Colorado River basin, January–December 1968

Sampling station number and location	Concentration (dissolved) (pg/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly average
Animas River:													
#11 above Durango, Colo	0.05	0.05	0.05	0.04	0.07	0.03	0.06	0.05	0.03	0.04	0.04	0.04	0.05
#12 Colo.-N. Mex. State line	.09	.07	.10	.05	.06	.06	.04	NS	NS	NS	NS	NS	.07
Colorado River:													
#1 at Silt, Colo	.25	.23	.27	.22	.08	.05	.13	.10	.22	.23	.21	.27	.18
#4 at De Beque, Colo	.25	.23	.22	.19	.12	.06	.12	.12	.19	.22	.21	.17	.18
#6 at Fruita, Colo	.14	.13	.16	.15	.22	.09	.13	.16	.13	.14	.13	.14	.14
#9 above Moab, Utah	.32	.26	.24	.43	.21	.20	.27	.29	.22	.16	.16	.19	.25
#10 below Moab, Utah	.72	.57	1.3	.42	.38	.38	.31	.26	.36	.31	.23	.24	.46
#31 at Page, Ariz	.13	.16	.15	.20	.17	.16	.15	.23	.18	.13	.15	.16	.17
#32 Lake Mead, Nev	.26	.23	.23	.25	.19	.20	.23	.27	.26	.17	.20	.21	.23
#33 Lake Havasu, Calif	.28	.28	.28	.26	.26	.18	.26	.24	.31	.24	NS	NS	.26
#30 at Yuma, Ariz	.17	.12	.15	.20	.10	.13	.18	.22	.13	.09	.10	.11	.14
Delores River:													
#21 at Bedrock, Colo	.33	.16	.39	.16	.14	.11	.23	.39	.41	.55	.44	.31	.30
#26 at Gateway, Colo	2.7	3.8	2.9	.78	.21	.44	.88	.94	3.6	2.1	1.5	1.7	1.80
Gunnison River:													
#5 at Grand Junction, Colo	.08	.04	.04	.05	.05	.04	.16	.17	.09	.10	.09	.08	.08
San Juan River:													
#14 below Farmington, N. Mex	.08	.05	.06	.07	.05	.07	.08	.05	.06	.05	.05	.03	.06
#15 above Mexican Hat, Utah	NS	.09	.08	.07	.15	.05	NS	NS	NS	NS	NS	NS	.09
#16 below Mexican Hat, Utah	NS	.08	.06	.06	.10	.06	NS	NS	NS	NS	NS	NS	.07
San Miguel River:													
#17 above Naturita, Colo	.04	.02	.03	.05	.04	.02	.04	.03	.06	.04	.01	.04	.04
#18 above Uravan, Colo	.09	.09	.11	.16	.09	.11	.11	.10	.13	.09	.12	.06	.11
#20 below Uravan, Colo	8.14	4.9	5.9	2.18	.59	.96	1.00	1.34	2.83	1.25	3.29	9.7	[a]3.40

[a] Mean of 52 separate analyses.
NS, no sample.

Table 2. Uranium in surface waters of the Colorado River basin, January–December 1968

Sampling station number and location	Concentration (dissolved) (μg/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly average
Animas River:													
#11 above Durango, Colo	1.2	1.4	1.2	1.1	1.4	0.3	1.5	0.6	2.0	3.1	3.2	2.2	1.6
#12 Colo.-N. Mex. State line	2.5	2.6	2.4	1.8	1.2	.8	2.8	NS	NS	NS	NS	NS	2.0
Colorado River:													
#1 at Silt, Colo	3.5	3.2	3.3	2.7	.8	1.9	2.7	1.6	3.7	4.9	5.0	5.3	3.2
#4 at De Beque, Colo	5.5	4.6	4.7	3.7	1.5	2.5	2.9	1.7	3.7	5.4	6.6	6.1	4.1
#6 at Fruita, Colo	7.5	8.1	7.9	6.6	4.3	3.9	7.2	5.8	11	13	9.1	8.7	7.8
#9 above Moab, Utah	9.3	9.1	10	8.8	4.9	2.0	6.0	8.0	14	12	7.9	9.6	8.5
#10 below Moab, Utah	10	10	12	11	6.0	2.2	8.8	8.2	15	14	13	9.4	10.0
#31 at Page, Ariz	6.8	7.4	7.4	7.0	7.9	8.3	6.1	3.7	5.6	7.2	6.8	6.5	6.7
#32 Lake Mead, Nev	7.0	7.8	6.8	7.2	6.5	7.1	6.1	5.5	7.5	8.6	8.9	8.3	7.3
#33 Lake Havasu, Calif	7.3	7.6	6.6	7.0	7.2	7.4	5.7	5.8	7.2	9.3	NS	NS	7.1
#30 at Yuma, Ariz	7.2	7.4	7.5	7.9	6.4	7.7	7.6	5.7	6.6	6.8	7.3	7.5	7.1
Delores River:													
#21 at Bedrock, Colo	7.4	7.0	8.5	3.6	1.6	.8	6.2	3.9	11	18	13	12	7.8
#26 at Gateway, Colo	25	31	23	15	5.7	6.0	8.2	15	32	36	24	40	21.7
Gunnison River:													
#5 at Grand Junction, Colo	10	7.7	11	6.8	3.4	5.1	14	10	15	14	8.9	7.3	9.4
San Juan River:													
#14 below Farmington, N. Mex	3.7	2.7	3.2	1.7	1.4	.8	2.9	2.3	4.1	4.5	4.5	2.7	2.9
#15 above Mexican Hat, Utah	NS	6.0	6.9	4.3	2.4	1.0	NS	NS	NS	NS	NS	NS	4.1
#16 below Mexican Hat, Utah	NS	6.6	6.3	5.0	2.8	1.2	NS	NS	NS	NS	NS	NS	4.4
San Miguel River:													
#17 above Naturita, Colo	2.8	3.3	3.3	1.6	1.6	.8	.7	.6	6.9	8.2	4.4	4.3	3.2
#18 above Uravan, Colo	5.2	5.0	4.4	3.4	1.4	.9	1.5	1.5	7.5	8.4	7.1	5.7	4.3
#20 below Uravan, Colo	46.7	9.9	10.1	8.1	3.4	1.0	10.9	26.8	27.5	29.4	48	86	[a]25.0

[a] Mean of 52 separate analyses.
NS, no sample.

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tions on RMN samples for 1968 is given in tables 1 and 2. Compared with results from the previous reporting period, 15 stations showed lower or unchanged concentrations of radium-226. Radium-226 concentrations at five stations showed significant percentage increases, but only two of these increases are regarded as significant because of the absolute concentrations involved.

Lead-210, polonium-210, and thorium (alpha) concentrations, while detectable in some of the quarterly composited samples, have been of no significance insofar as health hazards are concerned. Generally, higher concentrations were observed below the uranium mill at Uravan, Colo., than at other stations for which data were available. Gross alpha and gross beta radioactivity concentrations also are generally higher at the same station.

Stations located above and below the uranium mill at Moab, Utah, showed higher concentrations of gross alpha and gross beta radioactivities than did the other stations, except the one below Uravan. However, at Moab, the difference in the upstream and downstream averages is not striking. None of the gross alpha and gross beta results indicates a potential hazard aside from the possible inclusion of radium-226 and strontium-90 in the gross figures for alpha and beta.

Radium-226 concentrations (dissolved) in samples from the San Miguel River downstream of the uranium mill at Uravan, Colo., average 3.40 picograms per liter in 1968 as compared with annual averages for the two previous years of 1.57 (1967) and 1.93 (1966) picograms per liter and a mean of 1.18 from 1961 through 1967. At Gateway, Colo., on the Dolores River downstream of its confluence with the San Miguel, the radium-226 concentrations (dissolved) in water samples averaged 1.80 picograms per liter as compared with 1.22 and 1.20 picograms per liter for 1967 and 1966, respectively.

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(*5*) TALVITIE, N. A. and R. J. DEMINT. Radiochemical determination of strontium-90 in water using ion exchange. Anal Chem 37:1605 (1965).

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1967	December 1968

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Radioactivity in Washington Surface Water[1] July 1969-June 1970

Washington State Department of Social and Health Services

Radioanalysis of surface water samples collected throughout the State is one of the major functions of the Washington State Department of Social and Health Services radiation surveillance program. Some surface water samples are collected monthly or quarterly by the Washington State Department of Ecology. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department. Figure 1 shows the surface water sampling locations and code numbers.

All water is collected in 2-liter polyethylene bottles by grab sampling and is mailed to the State radiation laboratory in Seattle for analysis. Before sampling, 2 milliliters of concentrated nitric acid are added to each bottle to prevent loss of radioactivity through precipitation or adhesion.

Analytical procedures

Surface water samples are analyzed for gamma-ray emitters and then separated into

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[1] Summarized from "Environmental Radiation Surveillance in Washington State," Ninth Annual Repuort, July 1969–June 1970.

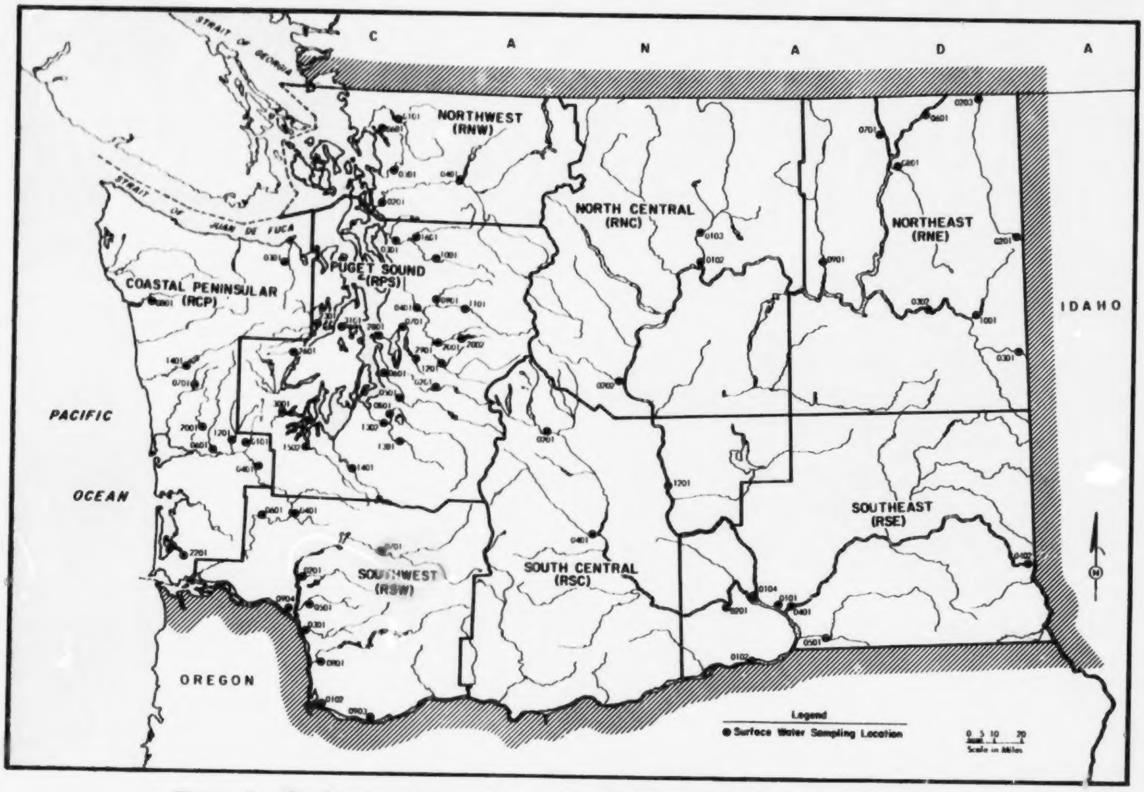
STRAIT OF GEORGIA
C A N A D A
NORTHWEST (RNW)
STRAIT OF JUAN DE FUCA
NORTH CENTRAL (RNC)
NORTHEAST (RNE)
PUGET SOUND (RPS)
COASTAL PENINSULAR (RCP)
IDAHO
PACIFIC
OCEAN
SOUTHEAST (RSE)
SOUTHWEST (RSW)
SOUTH CENTRAL (RSC)
OREGON
N
Legend
● Surface Water Sampling Location
0 5 10 20
Scale in Miles

Figure 1. Washington State surface water sampling locations with code numbers

suspended and soluble fractions for gross beta counting. All Columbia River samples are also analyzed for phosphorus-32, a pure beta-particle emitter which is not detectable in the gamma-ray scan. Table 1 gives the beta-particle efficiencies and detectable limits for the beta counters.

Table 1. Beta-particle efficiencies and detectability limits for the Washington State analysis

Radionuclide	Efficiency (percent)	Average back-ground (cpm)	Detect-ability limits[a] (pCi)
Strontium-yttrium-90	47	0.8	0.25
Yttrium-90	51	.8	.23
Phosphorus-32	48	.8	.24

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.

For the gamma radioanalysis, the samples are placed in stainless-steel Marinelli beakers as soon after receipt as possible. Distilled water is added when necessary to obtain 2,000 ml geometry. Table 2 presents the gamma-ray efficiencies and detectability limits for the gamma spectrometer. After analysis by gamma spectroscopy, surface water (except Columbia River) is filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace at 600° C., plancheted, weighed, and submitted for gross beta counting. The filtrate, evaporated to near dryness, is quantatively transferred to a tared planchet, dried, weighed, and submitted for gross beta counting.

Table 2. Gamma-ray efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average back-ground (cpm)	Detect-ability limits[a] (pCi)
Chromium-51	0.30–0.36	0.52	22.82	200
Ruthenium-106	.44– .56	.91	21.61	100
Scandium-46	.86– .92	2.45	4.71	20
Zirconium-95	.73– .79	6.96	5.68	10
Zinc-65	1.05–1.17	1.06	6.30	40

[a] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

The gamma analysis of the Columbia River samples is started approximately 14 days after collection. After the gamma spectroscopic analysis, Columbia River samples are divided into two aliquots. One aliquot is prepared for standard gross beta counting as described above, while the second aliquot is prepared for phosphorus-32 counting. The technique used for phosphorus-32 separation is a modification of published methods (*1-4*). After a waiting period of 15 days following collection to allow arsenic-76 and other short-lived interfering radionuclides to decay, the phosphorus is separated from the interfering radionuclides by precipitation as ammonium phosphomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3N ammonium hydroxide, transferred into a tared planchet, dried, ashed at 450° C., weighed, and counted for beta radioactivity.

Results

Table 3 presents the monthly average results for six Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 4 summarizes the beta radioactivity measurements from 5 other surface water stations from July 1969 through June 1970.

Table 5 presents the individual sample results from the tritium analyses performed by WERL for the State of Washington.

Discussion

Of the 50 river water samples analyzed from July 1969 through June 1970 (excluding the Columbia River), the total beta radioactivity ranged from <1 to 12 pCi/liter. The numerous sample results below the detectability limit of 1 pCi/liter precluded the determination of a precise average for comparison with previous years' data. Figure 2 shows the annual maximum and average gross beta radioactivity in surface waters other than the Columbia River for June 1963 through June 1970. The plotted average of 2.6 pCi/liter for 1970 actually is more representative of an upper limit based on the data shown in table 4.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford facility ranged from 2 to 373 pCi/liter. Monthly average concentrations of the beta emitter

Table 3. Monthly average radioactivity in Columbia River water, July 1969–June 1970

Location and type of analysis	Concentration (pCi/liter)											
	1969						1970					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code No. RNE 0601)												
Beta-particle												
Suspended[a]	NS	<1	NS	NS	<1	NS	NS	<1	NS	NS	<1	NS
Dissolved[a]	NS	3	NS	NS	2	NS	NS	2	NS	NS	2	NS
Total	NS	3	NS	NS	2	NS	NS	2	NS	NS	2	NS
Phosphorus-32[b]	NS	<1	NS	NS	<1	NS	NS	<1	NS	NS	<1	NS
Gamma-ray[b]												
Chromium-51	NS	<100	NS	NS	<100	NS	NS	<100	NS	NS	<100	NS
Zinc-65	NS	<20	NS	NS	<20	NS	NS	<20	NS	NS	<20	NS
Scandium-46	NS	<10	NS	NS	<10	NS	NS	<10	NS	NS	<10	NS
Richland (code No. RSE 0104)												
Beta-particle												
Suspended[a]	34 (4)	48 (4)	163 (5)	27 (3)	274 (4)	160 (5)	150 (4)	99 (4)	195 (5)	77 (3)	136 (4)	29 (5)
Dissolved[a]	48 (4)	82 (4)	118 (5)	148 (4)	99 (4)	101 (5)	88 (4)	16 (4)	45 (5)	58 (3)	55 (4)	29 (5)
Total	82	130	281	175	373	261	238	115	240	135	191	58
Phosphorus-32[b]	34 (4)	35 (4)	85 (5)	81 (4)	72 (4)	57 (5)	56 (4)	16 (4)	10 (5)	43 (3)	51 (4)	20 (5)
Gamma-ray[b]												
Chromium-51	682 (4)	1,398 (4)	1,271 (5)	2,362 (4)	1,362 (4)	1,044 (5)	1,190 (4)	317 (4)	349 (5)	580 (3)	698 (4)	290 (5)
Zinc-65	38 (4)	51 (4)	178 (5)	194 (4)	131 (4)	106 (5)	162 (4)	65 (4)	162 (5)	87 (3)	180 (4)	46 (5)
Scandium-46	64 (4)	77 (4)	255 (5)	917 (4)	301 (4)	233 (5)	602 (4)	110 (4)	434 (5)	136 (3)	724 (4)	98 (5)
Pasco (code No. RSE 0101)												
Beta-particle												
Suspended[a]	14	36	57	30	66	37	16	42	3	13	42	8
Dissolved[a]	17	33	37	56	68	55	30	22	5	12	48	15
Total	31	69	94	86	134	92	46	64	8	25	90	23
Phosphorus-32[b]	14	30	21	54	61	58	23	6	<1	6	56	10
Gamma-ray[b]												
Chromium-51	238	472	250	728	906	872	341	<100	<100	<100	530	200
Zinc-65	38	46	62	54	75	93	<20	31	26	38	72	<20
Scandium-46	21	55	142	85	115	109	44	66	<10	29	49	<10
McNary Dam (code No. RSE 0102)												
Beta-particle												
Suspended[a]	4	8	13	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved[a]	5	13	27	NS	NS	NS	NS	NS	NS	NS	NS	NS
Total	9	21	40	NS	NS	NS	NS	NS	NS	NS	NS	NS
Phosphorus-32[b]	2	10	28	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	<100	234	403	NS	NS	NS	NS	NS	NS	NS	NS	NS
Zinc-65	<20	<20	26	NS	NS	NS	NS	NS	NS	NS	NS	NS
Scandium-46	<10	<10	17	NS	NS	NS	NS	NS	NS	NS	NS	NS
Vancouver (code No. RSW 0102)												
Beta-particle												
Suspended[a]	8	3	4	3	2	NS	NS	NS	NS	NS	NS	NS
Dissolved[a]	10	6	11	11	9	NS	NS	NS	NS	NS	NS	NS
Total	18	9	15	14	11	NS	NS	NS	NS	NS	NS	NS
Phosphorus-32[b]	9	3	4	6	8	NS	NS	NS	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	197	131	278	307	143	NS	NS	NS	NS	NS	NS	NS
Zinc-65	<20	<20	<20	<20	<20	NS	NS	NS	NS	NS	NS	NS
Scandium-46	<10	<10	<10	<10	<10	NS	NS	NS	NS	NS	NS	NS
Longview (code No. RSW 0904)												
Beta-particle												
Suspended[a]	5	2	2	2	2	2	2	3	1	1	5	5
Dissolved[a]	7	5	7	9	6	6	5	5	3	3	7	6
Total	12	7	9	11	8	8	7	8	4	4	12	11
Phosphorus-32[b]	2	2	4	5	4	4	3	3	<1	1	5	3
Gamma-ray[b]												
Chromium-51	150	147	214	209	117	148	119	100	<100	<100	157	<100
Zinc-65	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	25	<20
Scandium-46	<10	<19	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

[a] Activity at time of counting. Strontium-90 yttrium-90 calibration standard.
[b] Results extrapolated to date of sample collection.
NS, no sample.

phosphorus-32 ranged from <1 to 85 pCi/liter. Figures 3 and 4 show the gross beta and phosphorus-32 results from the Columbia River at Pasco and Vancouver for 1963 through June 1970.

Monthly averages for chromium-51 ranged from <100 to 2,362 pCi/liter, and for zinc-65 the range was <20 to 194 pCi/liter. Figures 5 and 6 show the results for chromium-51 and zinc-65 at the Pasco and Vancouver stations on

Table 4. Beta radioactivity in Washington surface water [a] (except for Columbia River), July 1969–June 1970

Sampling location	Concentrations (pCi/liter)											
	1969						1970					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Cedar River:												
Landberg												
Suspended	<1	<1	<1	<1	<1	<1	<1	<1	<1 (2)	<1	<1	<1
Dissolved	<1	<1	1	<1	<1	1	<1	1	<1 (2)	<1	<1	1
Lake Whatcom:												
Bellingham												
Suspended	<1	<1	<1	NS	<1	<1	<1	<1	<1	<1	<1	1
Dissolved	3	2	3	NS	2	3	2	2	2	2	2	2
Puyallup River:												
Puyallup												
Suspended	<1	3	2	NS	<1	<1	<1	<1	<1	<1	<1	10
Dissolved	2	2	2	NS	2	2	1	1	1	2	1	2
Snake River:												
Pasco												
Suspended	<1	<1	<1	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved	2	7	4	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spokane River:												
Long Lake												
Suspended	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved	2	2	2	3	2	3	2	2	2	2	2	2

[a] Activity at time of counting. Strontium-yttrium-90 calibration standard. No detectable gamma activity present.
NS, no sample.

Table 5. Tritium in Washington surface water [a] July 1969–June 1970

Sampling location	Collection date (1969)	Concentration (nCi/liter)
Cedar River:		
Landsberg	8/22	<0.40
	11/21	.43
Columbia River:		
Longview	8/ 6	.50
	11/ 5	.69
McNary Dam	8/19	.89
Pasco	8/ 6	.93
	11/ 6	1.00
Richland	8/ 4	.95
	11/ 3	1.00
Vancouver	8/ 6	.84
	11/17	.91
Lake Whatcom:		
Bellingham	8/11	.75
	11/11	<.40
Snake River:		
Pasco	8/19	.50
Spokane River:		
Long Lake	8/ 9	.76
	11/16	.61

[a] Analyses performed by WERL, Las Vegas, Nev.

the Columbia River for 1963 through June 1970.

It should be emphasized the radionuclide concentrations found in the Columbia River cannot be extrapolated to the radiation discharges from modern nuclear power reactors. The concentrations in the Columbia River are due largely to old (up to 25 years) first technology plutonium production reactors utilizing direct single-pass cooling and do not reflect the environmental effects that would result from modern reactors.

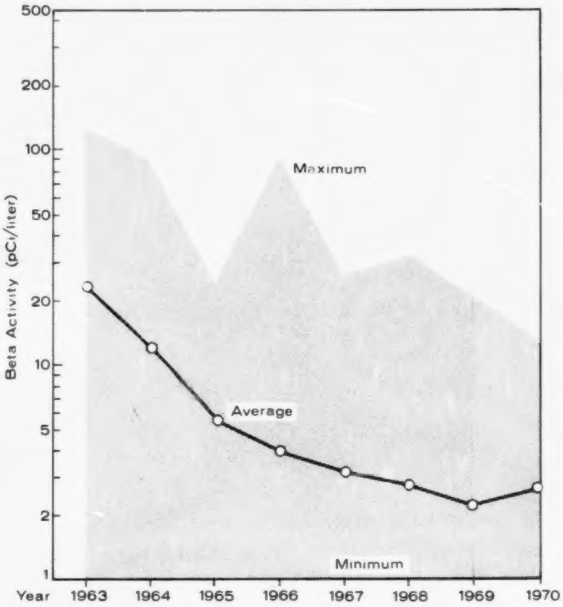

Figure 2. Average, maximum, and minimum beta radioactivity in surface water (excluding the Columbia River), 1963–1970

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1 nCi/liter of gross beta radioactivity in the absence of

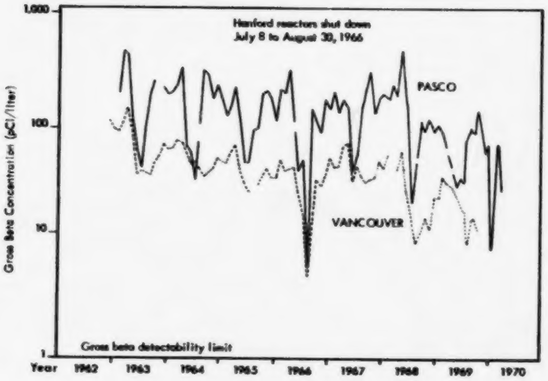

Figure 3. Gross beta radioactivity in Columbia River water, Pasco and Vancouver

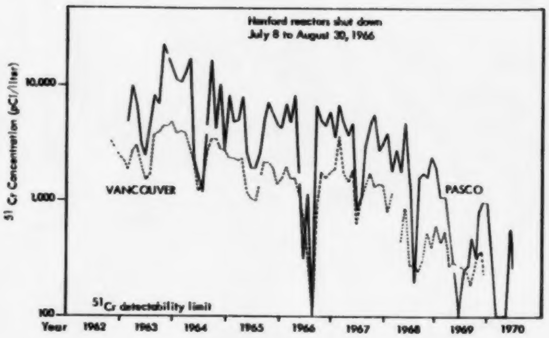

Figure 5. Chromium-51 in Columbia River water Pasco and Vancouver

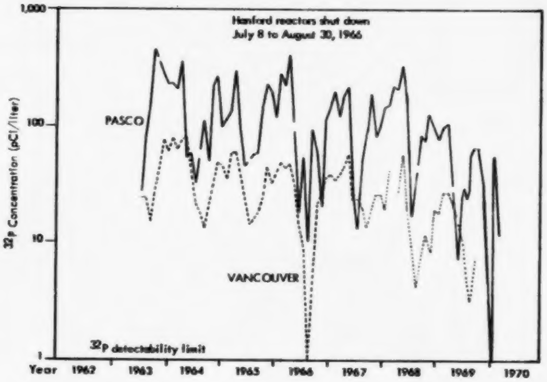

Figure 4. Phosphorus-32 in Columbia River water Pasco and Vancouver

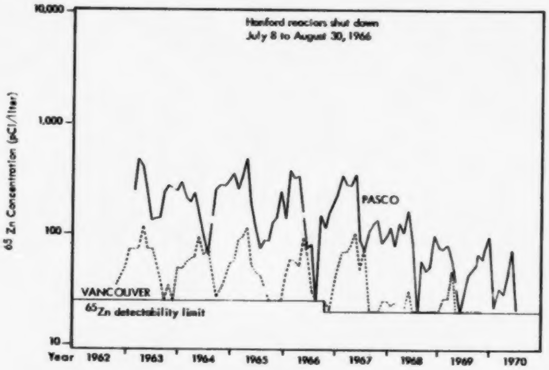

Figure 6. Zinc-65 in Columbia River water Pasco and Vancouver

strontium-90 and alpha emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are: chromium-51, 670 nCi/liter; zinc-65, 10 nCi/liter; and phosphorus-32, 7 nCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1968–June 1969	February 1971

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California State Department of Public Health, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican Air Monitoring Program	August–December 1970 and January 1971	October 1971
Plutonium in Airborne Particulates	January–March 1971	November 1971
Surface Air Sampling Program 80th Meridian Network, *HASL*	January–December 1969	January 1972

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1. Radiation Alert Network
November 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1971.

Higher than normal readings were reported for some stations, but none were reported higher than 17 pCi/m^3.

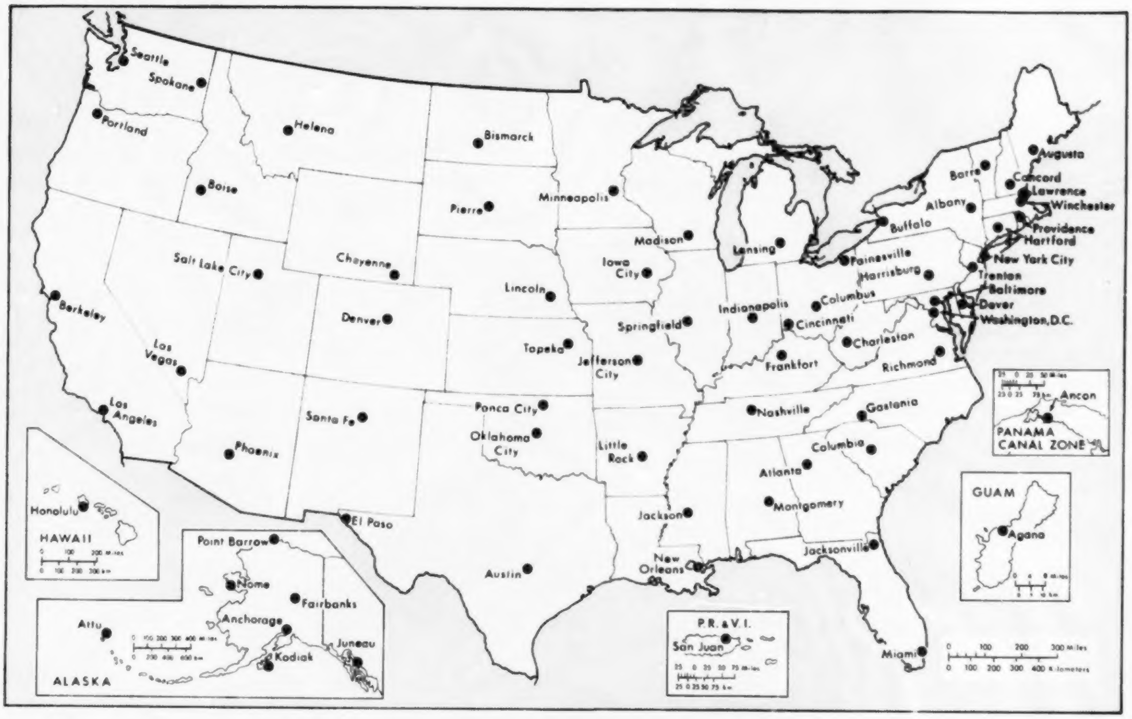
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Providence
Hartford
Buffalo
Madison
Lansing
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Topeka
Jefferson City
Charleston
Frankfort
Richmond
Las Vegas
Los Angeles
Ponca City
Santa Fe
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Ancon
PANAMA CANAL ZONE
Honolulu
HAWAII
Montgomery
GUAM
Agana
El Paso
Jackson
Point Barrow
Nome
Fairbanks
Austin
New Orleans
Jacksonville
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
Miami
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m³)
Ala:	Montgomery	17	6	1	2	2	88	2	88	98
Alaska:	Anchorage	4	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	0				0				
	Juneau	12	1	0	0	0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	10	14	2	6	0				
Ark:	Little Rock	1	0	0	0	0				
Calif:	Berkeley	18	2	0	1	1	13	1	13	0
	Los Angeles	2	2	1	2	0				
C.Z:	Ancon	12	0	0	0	0				
Colo:	Denver	21	5	0	3	2	6	(b)		
Conn:	Hartford	18	1	0	0	7	61	7	61	0
Del:	Dover	20	1	0	0	0				
D.C:	Washington	26	1	0	0	0				
Fla:	Jacksonville	20	1	0	1	3	36	3	36	10
	Miami	16	0	0	0	4	98	4	98	0
Ga:	Atlanta	19	2	0	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	19	1	0	0	5	64	(b)		
Idaho:	Boise	21	4	0	2	4	55	4	55	7
Ill:	Springfield	8	2	0	1	0				
Ind:	Indianapolis	19	2	0	1	0				
Iowa:	Iowa City	20	4	0	1	4	126	4	126	0
Kans:	Topeka	19	3	0	1	7	72	7	72	3
Ky:	Frankfort	0				0				
La:	New Orleans	18	1	0	0	4	22	(b)		
Maine:	Augusta	20	2	0	0	4	59	4	59	0
Md:	Baltimore	21	2	0	0	4	38	4	38	0
Mass:	Lawrence	20	1	0	0	6	107	5	87	0
	Winchester	20	2	0	1	7	160	7	160	0
Mich:	Lansing	20	1	0	1	3	8	3	8	1
Minn:	Minneapolis	20	4	0	1	7	102	7	102	25
Miss:	Jackson	16	2	0	1	2	13	2	13	2
Mo:	Jefferson City	21	3	0	1	6	57	6	57	3
Mont:	Helena	17	2	1	1	0				
Nebr:	Lincoln	10	10	1	3	3	45	3	45	17
Nev:	Las Vegas	20	5	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	8	92	8	92	5
N. Mex:	Santa Fe	16	2	0	1	3	37	3	37	0
N.Y:	Albany	19	1	0	0	0				
	Buffalo	20	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	14	17	1	4	0				
N. Dak:	Bismarck	21	5	0	1	5	25	5	25	3
Ohio:	Cincinnati	0				0				
	Columbus	4	2	0	1	0				
	Painesville	19	2	0	1	5	59	5	59	35
Okla:	Oklahoma City	0				0				
	Ponca City	20	9	0	1	4	28	4	28	0
Oreg:	Portland	19	1	0	0	11	177	11	177	3
Pa:	Harrisburg	11	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	18	2	0	0	4	13	4	13	0
S.C:	Columbia	15	7	0	2	2	46	2	46	0
S. Dak:	Pierre	21	10	1	2	0				
Tenn:	Nashville	21	3	0	1	4	32	4	32	2
Tex:	Austin	16	6	0	2	1	16	(b)		
	El Paso	13	8	1	2	0				
Utah:	Salt Lake City	29	1	0	1	7	46	7	46	29
Vt:	Barre	20	3	0	1	7	97	7	97	9
Va:	Richmond	16	1	0	0	3	67	3	67	17
Wash:	Seattle	13	1	0	0	10	107	(b)		
	Spokane	18	1	0	0	0				
W. Va:	Charleston	21	3	0	1	9	69	9	69	9
Wisc:	Madison	19	3	0	1	6	94	6	94	18
Wyo:	Cheyenne	18	5	1	3	0				
Network summary		1,015	17	0	1	174	72	5	65	10

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[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] November 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for November 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	30	0.2	0.0	0.1	([a])	0.4
Coral Harbour	30	.1	.0	.0	15	.3
Edmonton	30	.3	.0	.1	86	2.2
Ft. Churchill	30	.1	.0	.0	17	.4
Fredericton	30	.1	.0	.0	15	1.4
Goose Bay	30	.1	.0	.0	4	.6
Halifax	30	.1	.0	.1	15	2.4
Inuvik	30	.1	.0	.0	16	.3
Montreal	30	.1	.0	.1	27	1.5
Moosonee	30	.1	.0	.0	13	.5
Ottawa	30	.3	.0	.1	28	1.7
Quebec	30	.1	.0	.0	23	1.7
Regina	30	.6	.0	.1	109	.8
Resolute	30	.1	.0	.1	([a])	.1
St. John's, Nfld	30	.1	.0	.0	16	3.9
Saskatoon	30	.1	.0	.1	68	1.0
Sault Ste. Marie	20	.1	.0	.1	28	2.1
Thunder Bay	30	.1	.0	.0	27	2.0
Toronto	30	.2	.0	.1	30	1.3
Vancouver	30	.2	.0	.1	18	3.2
Whitehorse	30	.2	.0	.1	7	.2
Windsor	30	.1	.0	.1	25	1.3
Winnipeg	30	.1	.0	.0	43	1.0
Yellowknife	30	.1	.0	.0	35	.8
Network summary	710	0.6	0.0	0.1	30	1.3

[a] Precipitation, less than 0.1 inches.

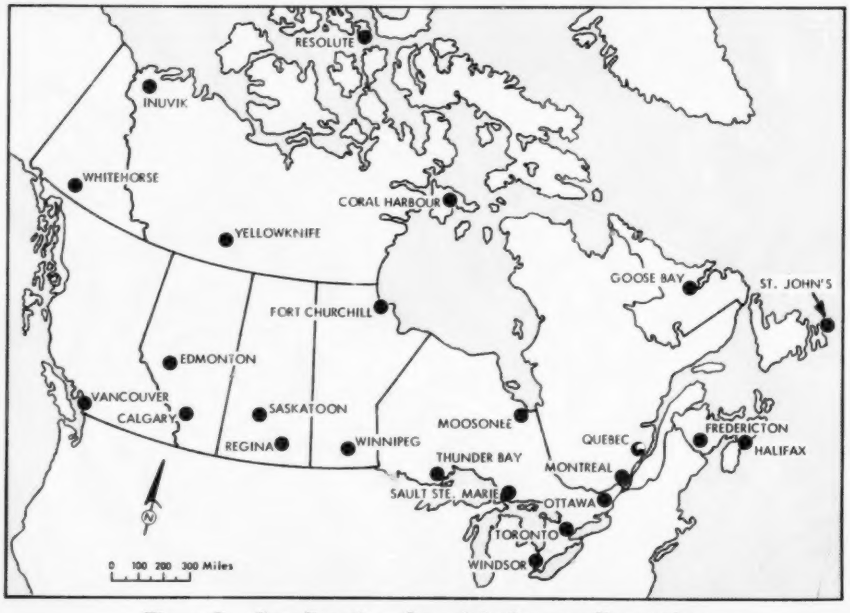
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare. Ottawa, Canada.

3. Pan American Air Sampling Program November 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The November 1971 air monitoring results from the participating countries are given in table 3.

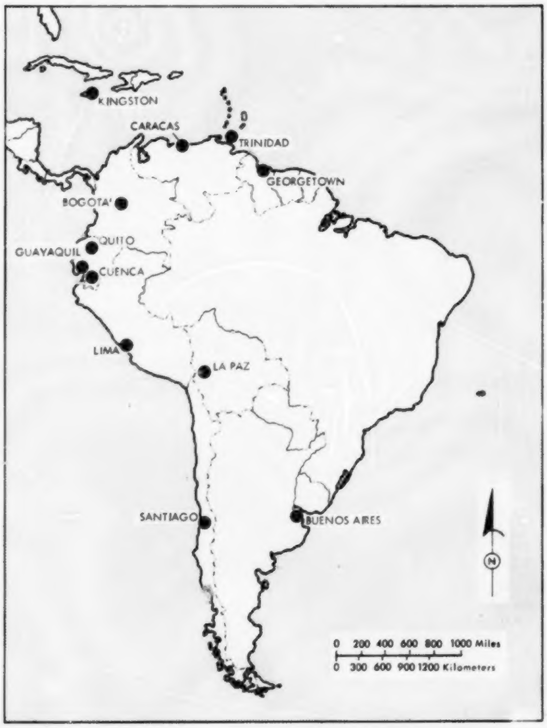

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	15	0.39	0.04	0.25
Chile:	Santiago	30	.48	.08	.26
Colombia:	Bogota	20	.33	.00	.03
Ecuador:	Cuenca	4	.14	.03	.07
	Guayaquil	8	.69	.14	.40
	Quito	18	.08	.00	.02
Guyana:	Georgetown	10	.05	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	8	.49	.18	.33
Venezuela:	Caracas	20	.04	.00	.02
West Indies:	Trinidad	14	.03	.01	.02
Pan American summary		147	0.69	0.00	0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program November 1971

Bureau of Radiological Health California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47

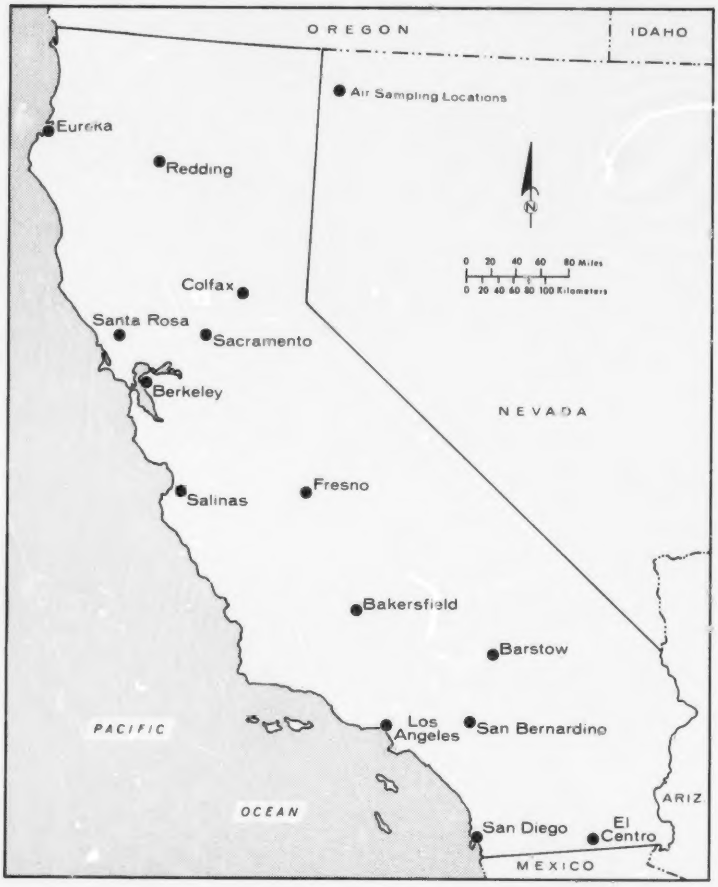
OREGON
IDAHO
Air Sampling Locations
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 4. California Air Sampling Program stations

millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for November 1971.

Table 4. Gross beta radioactivity in California air November 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Bakersfield	30	1.52	0.12	0.51
Barstow	30	20.31	.09	1.37
Berkeley	30	.37	.06	.17
Colfax	29	3.40	.04	.42
El Centro	28	2.03	.06	.57
Eureka	18	.30	.06	.16
Fresno	30	7.91	.07	.67
Los Angeles	11	1.57	.08	.61
Redding	29	1.15	.08	.22
Sacramento	30	4.22	.06	.45
Salinas	30	2.39	.06	.56
San Bernardino	30	2.57	.10	.51
San Diego	30	.71	.10	.25
Santa Rosa	30	.92	.04	.23
Summary	385	20.31	0.04	0.48

5. Plutonium in Airborne Particulates April-June 1971

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Office of Air Programs, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for April–June 1971 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Recent coverage in *Radiological Health Data and Reports:*

Issue	Period
July–December 1970	June 1971
January–March 1971	November 1971

Table 5. Plutonium in airborne particulates April–June 1971

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	^{239}Pu/^{238}Pu
Alaska:	Anchorage	[a]4 ±2	[a]44 ±5	[a]11 ±6
Ariz:	Phoenix	10 ±5	110 ±24	11 ±6
Colo:	Denver	9 ±5	125 ±28	14 ±8
Hawaii:	Honolulu	4 ±1	57 ±4	14 ±4
La:	New Orleans	4 ±1	75 ±7	19 ±5
Md:	Baltimore	5 ±1	82 ±10	16 ±4
N.Y:	Buffalo	5 ±2	104 ±10	21 ±9
N.C:	Gastonia	8 ±2	120 ±10	15 ±4
S.Dak:	Pierre	7 ±2	104 ±14	15 ±5
Tex:	Austin	NS		
Wash:	Seattle	7 ±3	131 ±17	19 ±8

[a] Composite of April and June only.
NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Air Surveillance Network August-September 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network, operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

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[1] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

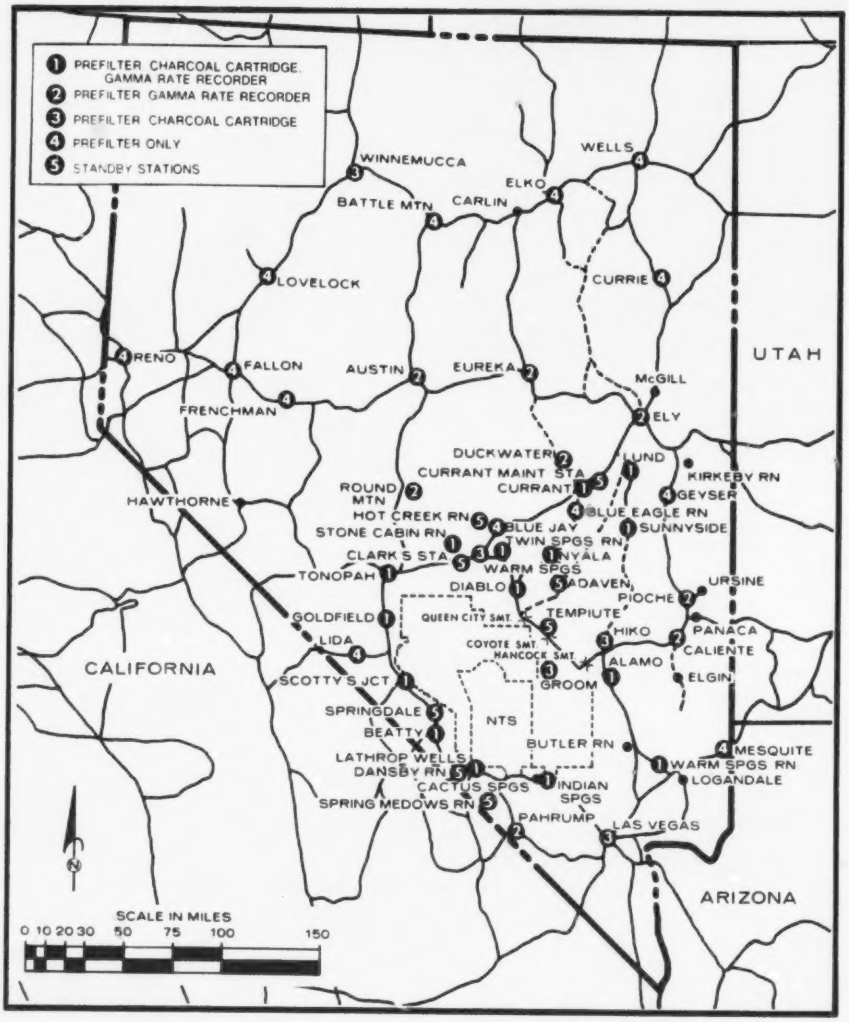
① PREFILTER CHARCOAL CARTRIDGE. GAMMA RATE RECORDER
② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
WINNEMUCCA
WELLS
ELKO
CARLIN
BATTLE MTN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
UTAH
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT STA
CURRANT
KIRKEBY RN
ROUND MTN
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
STONE CABIN RN
BLUE JAY
SUNNYSIDE
TWIN SPGS RN
CLARK'S STA
NYALA
TONOPAH
WARM SPGS
URSINE
DIABLO
ADAVEN
PIOCHE
GOLDFIELD
QUEEN CITY SMT.
TEMPIUTE
HIKO
PANACA
LIDA
COYOTE SMT.
HANCOCK SMT.
CALIENTE
CALIFORNIA
ALAMO
SCOTTY'S JCT
GROOM
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEDOWS RN
PAHRUMP
LAS VEGAS
N
ARIZONA
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. WERL Air Surveillance Network stations in Nevada

Sampling

Twenty-four-hour samples of airborne particulates are collected daily at each active station on 4-inch diameter, glass-fiber filters at a flow rate of about 350 m^3 of air per day. Samples may be collected for shorter periods to document specific radioactivity releases. Activated charcoal cartridges following the filters are used regularly for collection of radioiodines at 22 stations. The stations are operated by State health department personnel and by private individuals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS.

All charcoal cartridges are counted for 10 minutes in a gamma spectrometer. Data from those cartridges having a net gross gamma count rate greater than 300 cpm are analyzed by a computer matrix to quantitate individual radionuclides.

Analysis

The particulate filters are counted for gross beta activity as soon as they are received and at 5 and 12 days after collection. Samples are counted on gas-flow proportional counters calibrated over a range of beta energies from 0.1 to 1.8 MeV. A conservative efficiency value of 45 percent (corresponding to an average maximum beta energy of 0.5 MeV) is used for data conversion. Those filters with total gross beta activities of 500 cpm or greater are gamma scanned on a 4- by 4-inch sodium iodide (thallium-activated) crystal connected to a 400-channel gamma spectrometer. Individual radionuclides are quantitated from spectrometer data by the use of a computer and a matrix technique. The 5- and 12-day beta counts are used to extrapolate gross beta concentrations to mid-collection time for reporting. Extrapolation is accomplished by computer programs and is routinely based on a $T^{-1.2}$ decay. For known

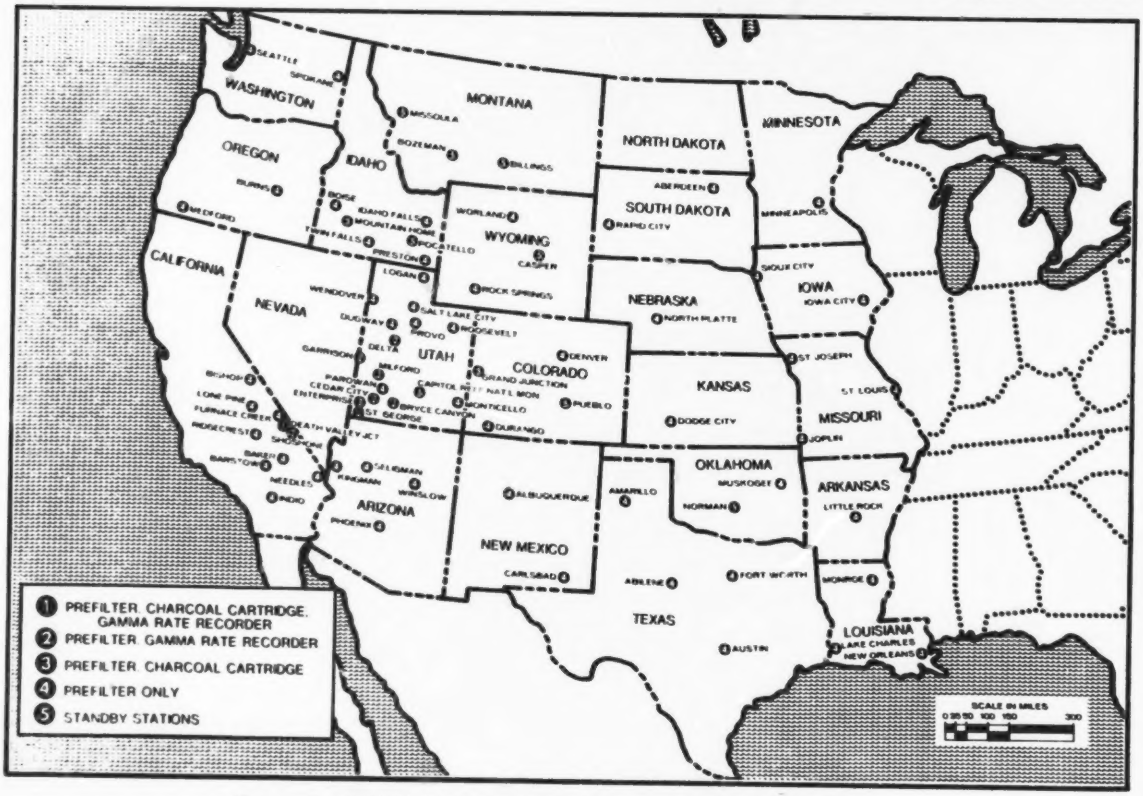
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
CALIFORNIA
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
BAKER
BARSTOW
NEEDLES
INDIO
SHOSHONE
DEATH VALLEY JCT
NEVADA
WENDOVER
GARRISON
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
UTAH
LOGAN
SALT LAKE CITY
DUGWAY
PROVO
ROOSEVELT
DELTA
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
BRYCE CANYON
CAPITOL REEF NATL MON
COLORADO
DENVER
GRAND JUNCTION
MONTICELLO
PUEBLO
DURANGO
ARIZONA
KINGMAN
SELIGMAN
WINSLOW
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
NEBRASKA
NORTH PLATTE
KANSAS
DODGE CITY
OKLAHOMA
MUSKOGEE
NORMAN
TEXAS
AMARILLO
ABILENE
FORT WORTH
AUSTIN
MINNESOTA
MINNEAPOLIS
IOWA
SIOUX CITY
IOWA CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
ARKANSAS
LITTLE ROCK
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
① PREFILTER. CHARCOAL CARTRIDGE. GAMMA RATE RECORDER
② PREFILTER. GAMMA RATE RECORDER
③ PREFILTER. CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
SCALE IN MILES
0 25 50 100 150 300

Figure 2. WERL Air Surveillance Network stations outside Nevada

Table 1. Summary of gross beta radioactivity concentrations in air, August 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Ariz:	Kingman	30	<0.1	0.2	0.4
	Phoenix	28	<.1	.1	.3
	Seligman	31	<.1	.2	.5
	Winslow	31	.1	.2	.5
Ark:	Little Rock	18	<.1	.2	.5
Calif:	Baker	27	<.1	.3	.5
	Barstow	30	<.1	.3	.5
	Bishop	30	.1	.3	.5
	Death Valley Junction	30	<.1	.3	1.0
	Furnace Creek	30	.1	.3	.5
	Indio	31	.1	.2	.4
	Lone Pine	29	<.1	.2	.5
	Needles	29	<.1	.2	.5
	Ridgecrest	30	.1	.2	.4
	Shoshone	31	.1	.2	.4
Colo:	Denver	19	<.1	.3	.5
	Durango	31	<.1	.2	.7
Idaho:	Boise	31	<.1	.3	.9
	Idaho Falls	22	.1	.3	1.0
	Preston	31	.1	.5	1.5
	Twin Falls	31	<.1	.3	.9
Iowa:	Iowa City	21	.1	.4	1.0
	Sioux City	26	<.1	.3	.8
Kans:	Dodge City	31	<.1	.1	.3
La:	Lake Charles	21	.1	.2	.6
	Monroe	17	<.1	.2	.4
	New Orleans	18	.1	.2	.7
Minn:	Minneapolis	22	.1	.3	.6
Mo:	Joplin	29	.1	.4	.8
	St. Joseph	31	.1	.4	.8
	St. Louis	31	.1	.4	.7
Nebr:	North Platte	26	<.1	.3	.9
Nev:	Alamo	29	<.1	.2	.3
	Austin	29	.1	.3	.5
	Battle Mountain	24	.1	.2	.6
	Beatty	31	.1	.3	.5
	Blue Eagle Ranch (Currant)	30	.1	.3	.5
	Blue Jay	31	<.1	.2	.3
	Caliente	30	.1	.2	.4
	Currant Ranch	31	<.1	.2	.5
	Currie	29	<.1	.3	.8
	Diablo	31	.1	.3	.5
	Duckwater	25	<.1	.2	.5
	Elko	29	<.1	.3	.6
	Ely	30	.1	.2	.5
	Eureka	31	<.1	.3	.5
	Fallini's Twin Springs Ranch	31	.1	.3	.5
	Fallon	31	.1	.3	.6
	Frenchman Station	31	<.1	.3	.8
	Geyser Maintenance Station	25	.2	.3	.6
	Goldfield	32	<.1	.2	.5
	Groom Lake	25	<.1	.2	.4
	Hiko	31	<.1	.2	.5
	Indian Springs	31	<.1	.2	.5
	Las Vegas	22	<.1	.2	.4
	Lathrop Wells	31	<.1	.3	2.2
	Lida	31	<.1	.2	.4
	Lovelock	31	<.1	.3	.8
	Lund	28	.1	.2	.6
	Mesquite	31	.1	.2	.5
	Nyala	30	<.1	.2	.5
	Pahrump	25	.1	.2	<.7
	Pioche	31	<.1	.2	.6
	Reno	21	.2	.3	.5
	Round Mountain	31	<.1	.2	.4
	Scotty's Junction	31	<.1	.3	.5
	Stone Cabin Ranch	31	<.1	.2	.4
	Sunnyside	27	<.1	.2	.4
	Tonopah	31	<.1	.3	1.0
	Tonopah Test Range	27	<.1	.2	.4
	Warm Springs Ranch	31	<.1	.2	.6
	Wells	31	<.1	.3	1.0
	Winnemucca	31	<.1	.3	.6
N. Mex:	Albuquerque	26	<.1	.2	.6
	Carlsbad	27	<.1	.2	.4
Okla:	Muskogee	31	<.1	.3	.8
Oreg:	Burns	29	<.1	.3	.6
	Medford	23	<.1	.3	.7
S. Dak:	Aberdeen	31	.1	.4	.9
	Rapid City	31	.1	.3	.8
Tex:	Abilene	29	<.1	.2	.7
	Amarillo	31	<.1	.3	.5
	Austin	11	.1	.2	.4
	Fort Worth	19	<.1	.3	.9

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, August 1971—Continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Utah:	Bryce Canyon	24	<.1	.2	.5
	Cedar City	27	<.1	.2	.6
	Delta	31	<.1	.2	.8
	Dugway	31	<.1	.3	.8
	Enterprise	30	.1	.2	.7
	Garrison	31	<.1	.2	.8
	Logan	31	.1	.3	.9
	Milford	30	<.1	.2	.7
	Monticello	28	<.1	.2	.5
	Parowan	31	<.1	.2	.7
	Provo	26	<.1	.3	.9
	Roosevelt	31	<.1	.2	.6
	Salt Lake City	30	<.1	.3	1.0
	St. George	31	<.1	.2	.5
	Wendover	31	.1	.3	.9
Wash:	Seattle	22	.1	.2	<1.4
	Spokane	18	.1	.3	.7
Wyo:	Rock Springs	31	<.1	.3	.7
	Worland	31	.2	.4	.9

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

Table 2. Summary of gross beta radioactivity concentrations in air, September 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Ariz:	Kingman	30	0.1	0.3	1.1
	Phoenix	30	.1	.2	.5
	Seligman	30	<.1	.3	.5
	Winslow	30	<.1	.2	.4
Ark:	Little Rock	17	<.1	.2	.4
Calif:	Baker	26	.1	.3	.5
	Barstow	30	<.1	.2	.6
	Bishop	30	<.1	.3	.9
	Death Valley Junction	30	<.1	.3	.9
	Furnace Creek	29	.1	.3	.9
	Indio	30	.1	.2	.4
	Lone Pine	30	<.1	.3	.8
	Needles	28	.1	.3	.4
	Ridgecrest	30	<.1	.2	.4
	Shoshone	30	.1	.2	.8
Colo:	Denver	21	<.1	.2	.3
	Durango	30	<.1	.3	.8
Idaho:	Boise	30	<.1	.2	.6
	Idaho Falls	20	.1	.2	.5
	Preston	30	<.1	.2	.6
	Twin Falls	30	<.1	.2	.5
Iowa:	Iowa City	21	<.1	.2	.4
	Sioux City	24	<.1	.2	.5
Kans:	Dodge City	30	<.1	.1	.3
La:	Lake Charles	20	<.1	.1	.4
	Monroe	19	.1	.1	.4
	New Orleans	20	<.1	.1	.3
Minn:	Minneapolis	20	<.1	.2	.6
Mo:	Joplin	29	<.1	.2	.5
	St. Joseph	30	<.1	.2	.5
	St. Louis	30	<.1	.2	.4
Nebr:	North Platte	26	<.1	.2	.4
Nev:	Alamo	30	.1	.2	.7
	Austin	28	<.1	.2	.8
	Battle Mountain	29	.1	.2	.7
	Beatty	30	<.1	.3	1.0
	Blue Eagle Ranch (Currant)	29	.1	.3	.9
	Blue Jay	30	.1	.2	.8
	Caliente	30	.1	.3	.8
	Currant Ranch	30	<.1	.2	.6
	Currie	31	<.1	.3	.8
	Diablo	30	.1	.3	1.0
	Duckwater	28	<.1	.2	.7
	Elko	30	<.1	.2	.6
	Ely	29	<.1	.3	.9
	Eureka	31	.1	.3	.9
	Fallini's Twin Springs Ranch	30	.1	.3	.9
	Fallon	30	<.1	.3	.5
	Frenchman Station	30	<.1	.3	.6

See footnote at end of table.

Table 2. Summary of gross beta radioactivity concentrations in air, September 1971 —Continued

Location		Number of samples	Concentration[a] (pCi/m^3)		
			Minimum	Average	Maximum
Nev:	Geyser Maintenance Station	9	.2	.4	.9
	Goldfield	30	<.1	.3	.9
	Groom Lake	28	.1	.3	.9
	Hiko	30	<.1	.3	.8
	Indian Springs	30	<.1	.3	.8
	Las Vegas	20	.2	.4	1.3
	Lathrop Wells	31	.1	.3	1.1
	Lida	30	.1	.3	.7
	Lovelock	30	<.1	.2	.6
	Lund	29	.1	.3	.9
	Mesquite	30	<.1	.3	.5
	Nyala	30	<.1	.3	.9
	Pahrump	21	.1	.2	.8
	Pioche	30	<.1	.2	.6
	Reno	27	<.1	.2	.5
	Round Mountain	29	.1	.3	.9
	Scotty's Junction	30	<.1	.3	1.0
	Stone Cabin Ranch	29	<.1	.2	.7
	Sunnyside	22	.1	.2	.7
	Tonopah	30	<.1	.3	.8
	Tonopah Test Range	20	<.1	.3	.9
	Warm Springs Ranch	30	.1	.2	.6
	Wells	30	<.1	.2	.6
	Winnemucca	31	.1	.2	.7
N. Mex:	Albuquerque	22	.1	.2	.5
	Carlsbad	29	<.1	.2	.5
Okla:	Muskogee	27	<.1	.1	.4
Oreg:	Burns	30	<.1	.2	.3
	Medford	23	<.1	.2	.5
S. Dak:	Aberdeen	30	<.1	.2	.5
	Rapid City	30	<.1	.2	.5
Tex:	Abilene	29	<.1	.2	.4
	Amarillo	30	<.1	.2	.5
	Austin	2	.1	.1	.1
	Forth Worth	21	<.1	.2	.5
Utah:	Bryce Canyon	21	.1	.2	.7
	Cedar City	30	.1	.3	.7
	Delta	29	<.1	.3	.7
	Dugway	30	<.1	.2	.7
	Enterprise	30	.1	.3	.6
	Garrison	30	.1	.3	.8
	Logan	29	<.1	.2	.6
	Milford	28	.1	.3	.8
	Monticello	26	<.1	.2	.3
	Parowan	30	<.1	.3	1.2
	Provo	29	.1	.3	.7
	Roosevelt	30	<.1	.2	.5
	Salt Lake City	30	<.1	.2	.6
	St. George	30	.1	.3	.7
	Wendover	30	<.1	.2	.6
Wash:	Seattle	21	.1	.1	.2
	Spokane	9	<.1	.2	.3
Wyo:	Rock Springs	30	<.1	.2	.6
	Worland	29	<.1	.2	.5

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1 pCi/m^3.

releases of radioactivity the decay rate is determined experimentally and is used in the extrapolations.

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates during August 1971; table 2 presents the data for September 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06–0.07 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3.

From gamma spectrometry results in August, zirconium-niobium-95, ruthenium-106, and cerium-144 from worldwide fallout were identified in varying combinations on filters collected in Colorado, Iowa, Louisiana, Minnesota, and Texas. The highest concentrations of these radionuclides, respectively, were 0.2 pCi/m^3 (Iowa City and Minneapolis), 0.4 pCi/m^3 (Denver), and 0.5 pCi/m^3 (Lake Charles). From the September results, zirconium-niobium-95 was identified on filters from California, Idaho, and Nevada. The highest concentration was 0.3 pCi/m^3 at Alamo, Duckwater, Goldfield, and Indian Springs, Nev. No radioactivity above background levels was identified on any of the charcoal cartridges collected in August or September.

Complete summaries of daily station results are distributed to EPA regional offices and State health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, January-March 1971 [1]

Office of Radiation Programs
Environmental Protection Agency

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

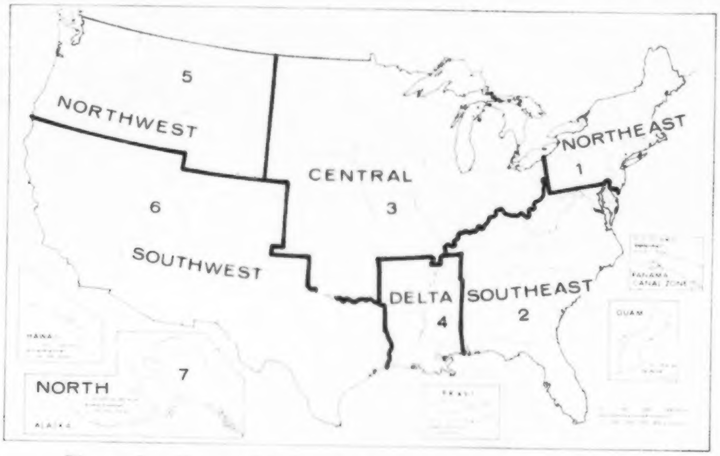

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

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Table 1. Strontium-90 in human bone, January–March 1971

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c,d] (pCi/kg bone)	Calcium concentration (g/kg bone)[d]	^{90}Sr/Ca (pCi/g)
Northeast:						
Massachusetts	V	1	M	81.5 ±9.3	28.2	2.89
	V	1	F	74.6 ±9.1	26.3	2.84
New York	V	2	M	50.6 ±7.0	25.1	2.01
Massachusetts	V	3	F	34.5 ±7.3	35.4	.98
Pennsylvania	V, R, I	5	F	109.9 ±9.4	43.4	2.53
New Hampshire	V	9	M	104.9 ±10.6	38.1	2.75
Pennsylvania	V, R, I	10	F	31.4 ±5.2	27.3	1.15
New York	V	14	M	53.1 ±8.1	31.6	1.68
Pennsylvania	V, R, I	14	M	129.9 ±19.3	89.3	1.45
	V, R, F	17	M	208.3 ±21.3	95.5	2.18
New York	V	19	M	103.9 ±9.5	44.0	2.36
	V	20	M	43.4 ±7.3	34.4	1.26
	V	21	F	49.1 ±7.1	38.6	1.27
	V	21	M	37.4 ±6.1	28.1	1.33
Pennsylvania	V	23	M	40.7 ±6.5	44.9	0.91
New York	V	23	M	64.0 ±8.2	51.1	1.25
	V	23	M	111.4 ±10.5	52.3	2.13
	V	24	M	55.3 ±8.8	38.4	1.44
Pennsylvania	V	24	M	77.2 ±9.0	48.3	1.60
New York	V	25	F	73.2 ±9.4	54.2	1.35
Southeast:						
Maryland	V	1	M	69.1 ±8.4	38.6	1.79
South Carolina	V	2	M	142.8 ±11.5	38.8	3.69
Maryland	V	6	M	69.2 ±10.6	33.8	2.05
	V	7	F	52.7 ±8.1	26.5	1.98
	V	9	F	60.2 ±10.9	30.0	2.01
	V	10	M	117.8 ±14.8	41.9	2.81
North Carolina	V, R	11	M	63.7 ±10.2	32.6	1.95
Maryland	V	13	F	77.1 ±10.9	47.0	1.64
	V	14	M	121.2 ±9.9	54.8	2.21
	V	14	M	121.3 ±9.1	49.6	2.44
	V	15	M	52.2 ±7.6	40.9	1.28
	V	16	F	93.9 ±12.3	45.6	2.06
	V	17	F	124.3 ±15.0	54.0	2.30
	V	17	M	102.6 ±12.8	56.1	1.83
	V	17	M	69.9 ±9.3	43.1	1.62
	V	17	F	211.2 ±17.6	62.9	3.36
	V	18	M	78.5 ±7.7	48.3	1.62
Tennessee	V	18	M	62.3 ±9.3	44.5	1.40
Virginia	V	18	M	54.4 ±7.7	27.5	1.97
South Carolina	V	18	M	138.6 ±13.0	54.7	2.53
Maryland	V	18	M	137.1 ±12.4	46.4	2.96
South Carolina	V	19	M	104.3 ±8.4	25.4	4.10
Maryland	V	19	F	105.8 ±13.9	58.2	1.82
Delaware	V	19	M	67.9 ±9.8	52.8	1.29
Virginia	V	20	M	75.2 ±8.9	47.0	1.60
Maryland	V	20	M	84.9 ±12.1	55.0	1.54
	V	21	M	89.6 ±10.9	54.2	1.65
	V	21	F	64.2 ±12.1	50.6	1.27
	V	21	M	99.6 ±12.0	42.6	2.34
	V	21	M	62.7 ±7.6	37.5	1.67
	V	22	M	85.7 ±10.9	46.4	1.85
	V	23	M	45.4 ±7.3	39.9	1.14
	V	23	M	75.4 ±9.1	57.5	1.31
	V	23	M	76.0 ±10.1	56.8	1.34
	V	23	F	42.7 ±7.4	37.8	1.13
	V	23	M	63.4 ±7.6	41.3	1.53
	V	23	M	54.7 ±7.9	35.9	1.52
	V	23	M	46.9 ±8.2	43.5	1.08
	V	24	M	64.5 ±8.7	42.2	1.53
Tennessee	V	24	M	122.5 ±10.8	53.9	2.27
Maryland	V	24	M	66.2 ±9.1	48.5	1.37
	V	24	F	44.2 ±8.3	35.8	1.24
	V	24	M	56.3 ±8.4	43.4	1.30
	V	24	M	92.2 ±10.3	45.0	2.05
	V	24	M	124.7 ±13.3	65.8	1.90
South Carolina	V	25	F	114.7 ±10.9	49.4	2.32
Maryland	V	25	F	50.1 ±7.0	56.5	.89
	V	25	M	170.2 ±13.6	53.5	3.18
Central:						
Ohio	V	1	F	52.0 ±9.2	33.0	1.57
Wisconsin	V	1	M	104.3 ±12.8	41.7	2.50
	V	2	M	93.0 ±10.9	34.3	2.71
	V	2	F	56.9 ±7.6	39.2	1.45
Ohio	V	3	M	81.8 ±9.6	29.2	2.80
Wisconsin	V	4	F	70.6 ±9.1	35.1	2.01
Illinois	V	4	F	77.5 ±9.7	30.9	2.51
Wisconsin	V	5	F	85.1 ±10.3	33.0	2.58
Ohio	V	6	M	56.2 ±9.0	35.7	1.57
	V	7	M	65.7 ±9.6	42.1	1.56
	V	8	M	89.1 ±9.5	39.0	2.28
Michigan	V	14	M	58.9 ±8.3	41.8	1.41
Ohio	V	15	M	100.0 ±9.9	56.9	1.76
Michigan	V	16	M	147.9 ±12.7	66.5	2.22
Ohio	V	16	M	106.6 ±9.9	48.5	2.20
	V	16	M	104.7 ±11.5	63.1	1.66
	V	16	M	99.9 ±11.0	55.3	1.81
	V	17	F	100.2 ±12.2	55.5	1.81

See footnotes at end of tabl

Table 1. Strontium-90 in human bone, January–March 1971—continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c,d] (pCi/kg bone)	Calcium concentration (g/kg bone)[d]	^{90}Sr/Ca (pCi/g)
Central:						
Ohio	V	18	M	117.2±12.3	62.1	1.89
	V	18	M	95.3±11.6	54.9	1.74
	V	18	M	165.6±15.6	55.6	2.98
	V	18	M	113.8±12.2	67.2	1.69
Michigan	V	18	F	147.4±10.4	53.8	2.74
Ohio	V	19	M	107.4±11.2	58.8	1.83
	V	19	M	109.1±13.8	63.3	1.72
	V	20	M	80.3±8.9	58.5	1.37
	V	20	F	97.1±10.5	52.6	1.84
	V	20	F	82.2±9.2	57.1	1.44
	V	20	F	95.0±12.3	57.7	1.65
	V	21	F	121.9±14.8	64.4	1.89
	V	21	M	94.1±8.8	46.1	2.04
	V	22	M	72.1±8.5	59.0	1.22
	V	22	M	64.5±9.9	51.8	1.25
	V	22	M	81.8±9.9	61.2	1.34
	V	22	M	94.9±10.4	52.6	1.80
Michigan	V	23	M	79.2±8.1	48.1	1.65
Ohio	V	23	M	75.8±11.6	63.8	1.19
	V	24	F	107.9±10.0	41.8	2.58
	V	24	M	84.1±11.6	67.6	1.24
Michigan	V	25	M	88.1±10.1	49.8	1.77
Ohio	V	25	F	54.1±8.9	54.4	.99
	V	25	F	96.0±10.8	72.3	1.33
	V	25	M	72.4±9.0	66.7	1.09
Delta:						
Louisiana	R	3	F	183.4±14.6	72.0	2.55
Northwest:						
Oregon	V	18	M	55.0±9.6	63.2	.87
	V	20	M	84.6±9.6	55.3	1.53
	V	23	M	61.4±8.8	57.1	1.07
Southwest:						
California	V	17	F	60.7±8.2	53.8	1.13
Texas	V	17	M	59.4±8.2	50.0	1.19
	V	24	M	41.2±8.4	38.4	1.07

[a] Type of bone, V, vertebrae; R, rib; I, ilium; F, femur.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.
[d] Sample preparation is not uniform at the various collection sites, and these ratios are not to be taken as absolute. This should not materially affect the ^{90}Sr/Ca ratios.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January–March) of 1971 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of data at appropriate stages in the program (*2–6*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1970	September 1971

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY, Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

(*6*) BARATTA, E. J., E. S. FERRI, and M. A. WALL. Strontium-90 in human bones in the United States, 1962–1966. Radiol Health Data Rep 11:183–186 (April 1970).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Feed Materials Production Center and the Savannah River Plant.

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1. Feed Materials Production Center[2]
January-June 1971

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project are concerned with the processing of high-grade uranium concentrates into metallic uranium. These processes include acid digestion of the concentrates, organic phase extraction of uranyl nitrate, subsequent conversion of the uranyl nitrate to uranium oxide and tetrafluoride, reduction to uranium metal, and fabrication of the metal into fuel elements. The project also includes plants for sampling of the concentrates and recovery of uranium from various residues. The final product is used in the nation's production reactors.

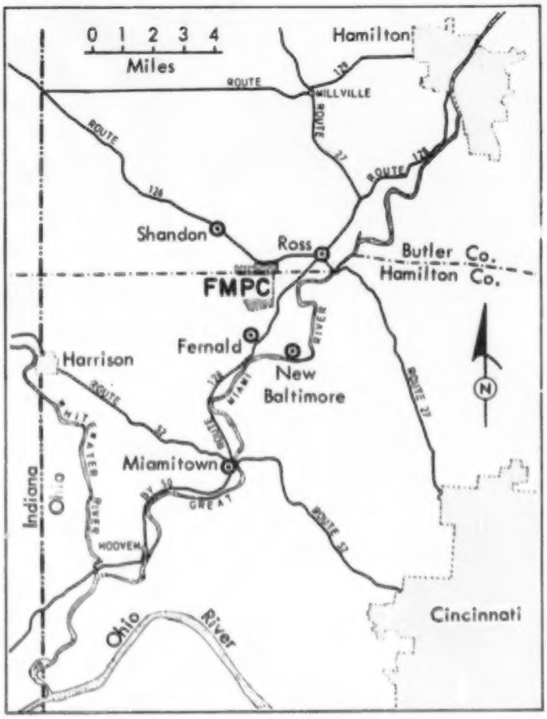

Figure 1. Area map of Feed Materials Production Center

The project also processes thorium to produce purified thorium compounds and metal. The production methods are similar to those used in producing uranium.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Feed Materials Production Center Environmental Monitoring, Semiannual Report for the First Half of 1971 (NLCO-1085)."

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. An environmental monitoring program has been established to determine the concentrations of radioactive materials in the water and air outside the project.

Air monitoring

Air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and gross alpha and gross beta radioactivity. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the project.

In previous reports, data were given for offsite air samples. Collection of these random, short-term samples was discontinued at the end of 1970 because of the questionable reliability of the results. Plans are now underway to construct six permanent sampling locations along the project boundary. Continuous samples collected at these locations will give better data regarding uranium and radioactivity in the nearby offsite air. Concentrations of uranium and alpha and beta radioactivity of airborne particulates are given in table 1.

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1971

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Alpha radioactivity[a] (pCi/m³)			Beta radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Southwest	26	0.08	<0.01	0.02	0.07	<0.001	0.02	0.43	0.04	0.19
Northwest	26	.13	<.01	.02	.14	<.001	.02	.52	.04	.20
Northeast	26	.08	<.01	.02	.08	<.001	.02	.55	.03	.19
Southeast	26	.07	<.01	.02	.06	<.001	.02	.40	.02	.18
Summary	104	.13	<.01	.02	.14	<.001	.02	.55	.02	.19

[a] AEC radiation protection standard—2 pCi/m³ (natural uranium).
[b] AEC radiation protection standard—1 nCi/m³ (thorium-234).

The results of sampling indicate that the concentrations at onsite locations averaged 1.0 percent, 1.0 percent, and 0.02 percent of the AEC standards for uranium, alpha radioactivity and beta radioactivity.

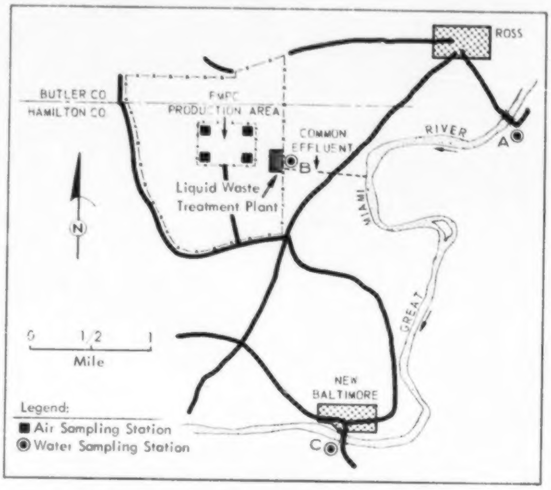

Figure 2. Air and water sampling stations Feed Materials Production Center

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process wastewater. The effluents from the plants are collected at a general sump for additional treatment and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then combined with three other types of project wastewater and discharged via a common effluent outfall into the Great Miami River. At location B, a Parshal-Flume-type water sampler collects samples of the combined effluent stream which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream (location A); a continuous sample is taken for a 24-hour period downstream (location C), and at least one sample is analyzed each week. All samples are analyzed for uranium, gross alpha and gross beta radioactivity, and radium-228, a daughter of thorium-232. Since radium-228 has the lowest AEC standard, control of this radionuclide and of the gross radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate that each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for January–June 1971 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	March 1971
July–December 1970	September 1971

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center, January–June 1971

Location	Number of samples	Uranium[a] (pCi/liter)			Alpha radioactivity[b] (pCi/liter)			Beta radioactivity[b] (pCi/liter)			Number of samples	Radium-228[c] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Sewer outfall[d] (location B)	181	182	<1	2	1,002	<1	8	921	<1	54	11	0.06	<0.01	0.02
Upstream from outfall (location A)	27	20	<1	4	39	<1	22	40	4	18	6	.9	<.01	.4
Downstream from outfall (location C)	27	6	<1	2	41	<1	4	40	9	18	6	.9	<.01	.4

[a] AEC standard—20 nCi/liter (natural uranium).
[b] AEC standard—3 nCi/liter (certain mixtures of alpha and beta emitters).
[c] AEC standard—30 pCi/liter (radium-228).
[d] Concentrations in the river as calculated from sewer outfall sample results.

2. Savannah River Plant[3]
January-June 1971

E. I. DuPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. DuPont de Nemours and Company, occupies an area of 310 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square-mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

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[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1971" (DPSPU 71-30-16).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 3). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background radioactivity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

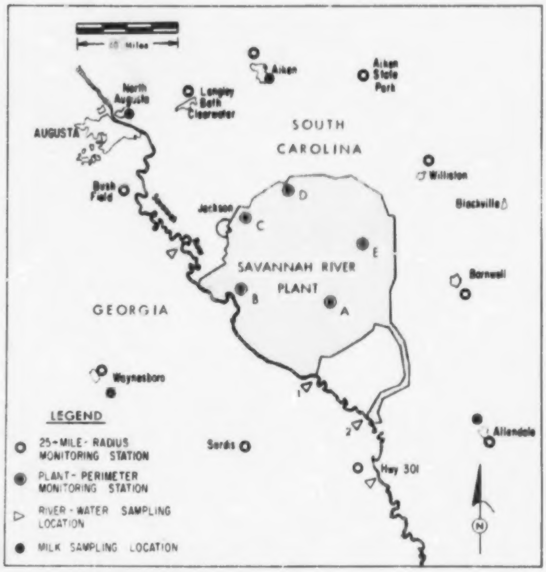
10 Miles
Aiken
Aiken State Park
North Augusta
Langley Bath Clearwater
AUGUSTA
SOUTH CAROLINA
Williston
Blackville
Bush Field
Jackson
D
C
E
SAVANNAH RIVER PLANT
B
A
Barnwell
GEORGIA
Waynesboro
1
2
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION
Sardis
Hwy 301
Allendale
N

Figure 3. Environmental sampling locations Savannah River Plant

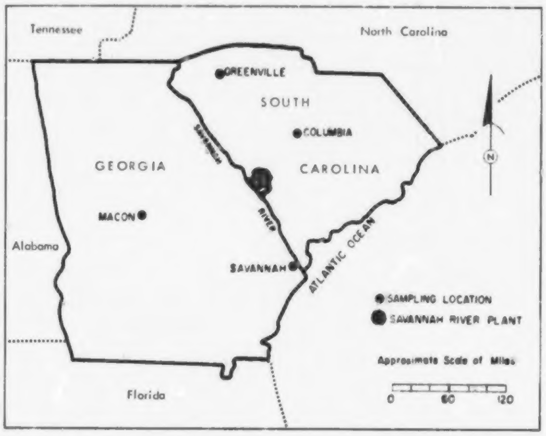
Tennessee
North Carolina
GREENVILLE
SOUTH
COLUMBIA
CAROLINA
GEORGIA
Savannah River
MACON
Alabama
SAVANNAH
ATLANTIC OCEAN
N
SAMPLING LOCATION
SAVANNAH RIVER PLANT
Approximate Scale of Miles
0
60
120
Florida

Figure 4. Distant air monitoring stations Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separation areas, was obscured by fallout. The influence of nuclear tests, which resumed in September 1961, is shown in figure 5. The present low levels of atmospheric activity are attributed to the moratorium on above-ground nuclear tests, which began in 1962. The slightly increasing trend (1967 through 1970) is attributed to fallout from atmospheric testing by nations who did not agree to the moratorium. Some increases typically occur each spring as a result of the mixing of the stratospheric debris into the troposphere. The average beta concentration in air increased from 0.17 pCi/m^3 to 0.33 pCi/m^3 during the first half of 1971. Gamma-emitting radionuclides in fallout were cesium-134, -137, cerium-141, -144, ruthenium-103, -106, and zirconium-niobium-95.

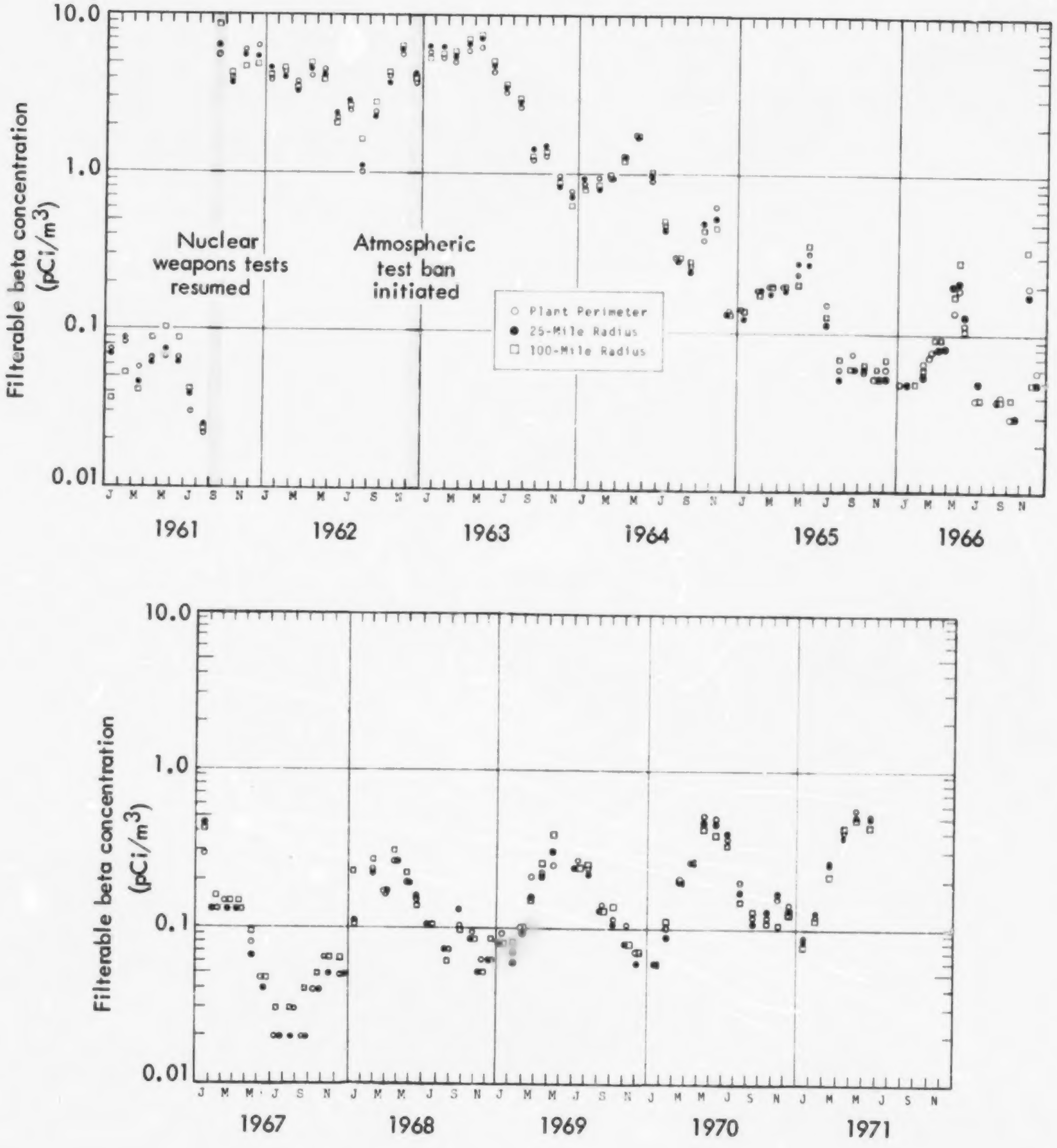

Figure 5. Influence of weapons tests

Radioactivity in air, determined from filter analyses, is shown in table 3. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. The January–June 1971 concentrations of filterable beta radioactivity (0.33 pCi/m^3) and alpha radioactivity (0.9 pCi/m^3) in air were 0.33 and 1.3 percent of the respective AEC standards. Tritium oxide concentrations

Table 3. Radioactivity in air, Savannah River Plant, January–June 1971

Sampling points	Alpha radioactivity[a] (fCi/m^3)			Nonvolatile beta radioactivity[b] (pCi/m^3)			^{131}I[c] average	Special radionuclides in composite samples (pCi/m^3)					
	Maximum	Minimum	Average	Maximum	Minimum	Average		^{89,90}Sr	^{137}Cs	^{141,144}Ce	^{103,106}Ru	^{95}Zr-Nb	^{7}Be
Plant perimeter:													
A	1.3	0.5	0.8	0.70	0.10	0.35	ND	0.01	0.01	0.07	0.10	0.18	0.23
B	2.1	.7	1.0	.69	.06	.31	ND						
C	1.6	.6	.9	.74	.09	.34	ND						
D	1.3	.4	1.0	.86	.08	.41	ND						
E	1.0	.5	.8	.68	.08	.34	ND						
Average			.9			.35	ND						
25-mile-radius:													
Aiken Airport	1.7	.4	.8	.67	.06	.31	ND	.01	.01	.07	.09	.17	.24
Aiken State Park	1.6	.4	.8	.75	.08	.30	ND						
Allendale	1.5	.5	1.1	.67	.09	.32	ND						
Barnwell	1.8	.5	1.3	.66	.08	.32	ND						
Bush Field	1.3	.7	1.0	.76	.08	.33	ND						
Langley	1.6	.7	1.4	.86	.09	.36	ND						
Sardis	1.2	.4	.8	.68	.06	.31	ND						
Waynesboro	1.4	.7	1.0	.75	.09	.35	ND						
Williston	1.5	.4	1.0	.71	.08	.32	ND						
Highway 301	1.3	ND	1.0	.73	.09	.32	ND						
Average			1.0			.32	ND						
Distant air-monitoring:													
S.C.:													
Columbia	2.4	ND	1.1	.93	.06	.34		.01	.02	.08	.09	.19	.26
Greenville	1.2	.5	.8	.65	.06	.34							
Ga.:													
Macon	1.8	ND	.8	.66	.04	.28							
Savannah	1.8	ND	.7	.73	.03	.32							
Average			.8			.32							

[a] AEC radiation protection standard–70 fCi/m^3, sensitivity of analysis—0.3 fCi/m^3.
[b] AEC radiation protection standard–100 pCi/m^3, sensitivity of analysis—0 006 pCi/m^3.
[c] AEC radiation protection standard—100 pCi/m^3, sensitivity of analysis—0.02 pCi/m^3.
ND, nondetectable.

Table 4. Total fallout deposited, Savannah River Plant, January–June 1971

Sampling points	Radionuclide concentration (nCi/m^2)								
	Alpha[a]	Strontium-89	Strontium-90	Cesium-137	Cerium-141,-144	Zirconium-niobium-95	Ruthenium-103,-106	Iodine-131	Beryllium-7[b]
Plant perimeter:									
A	3.5	1.3	0.8	1.8	10.2	10.8	6.1	ND	40.2
B	4.3	1.0	.7	1.7	13.9	13.4	6.8	ND	48.4
C	4.3	2.0	.8	2.1	15.3	14.7	7.1	ND	54.3
D	3.3	1.8	.7	1.6	13.0	10.1	6.5	0.5	39.3
E	3.1	1.8	.8	1.9	13.4	14.9	6.1	ND	47.7
Average	3.7	1.6	.8	1.8	13.2	12.8	6.5	.1	46.0
25-mile radius:									
Aiken Airport	2.9	1.4	.9	2.1	14.9	20.6	6.5	ND	48.2
Aiken State Park	6.6	1.3	.8	1.8	10.3	13.7	5.6	ND	39.3
Allendale	3.7	1.5	.7	1.6	11.5	15.2	5.8	ND	40.5
Barnwell	4.5	1.1	.5	1.2	7.8	10.7	5.1	ND	27.3
Bush Field	4.0	.6	.8	1.9	14.8	16.9	6.0	ND	51.4
Langley	4.9	1.6	1.0	2.4	13.4	17.4	7.1	ND	53.7
Sardis	5.6	1.1	.6	1.7	9.6	15.5	5.9	ND	33.3
Waynesboro	3.1	1.6	.8	2.0	11.7	16.2	6.3	ND	41.7
Williston	3.0	1.5	.7	1.8	10.3	13.4	5.5	ND	40.7
Highway 301	2.1	.5	.7	1.2	7.2	7.8	5.8	ND	25.1
Average	4.0	1.2	.8	1.8	11.2	14.7	6.0	ND	40.1

[a] Multiply by 10^{-2}.
[b] A naturally occuring radionuclide.
ND, less than the sensitivity of analysis.

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in air, at the plant perimeter and at the 25-mile-radius stations, did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during January–June 1971 averaged 37 nCi/m^2 at the plant perimeter locations and 36 nCi/m^2 at 25-mile-radius locations; comparable values for the last half of 1970 were 17 and 15 nCi/m^2 (excluding naturally occurring beryllium-7). Deposition at each sampling location is presented in table 4.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 6). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. The reactors are cooled and moderated by heavy water which, in turn, is cooled by river water in heat exchangers. This arrangement prevents irradiation of the river water, so that radioactivity is discharged into the river water only on the rare occasions when small quantities of moderator are lost by heat exchanger leaks.

The irradiated fuel (canned to prevent leaching of radionuclides) discharged from a reactor is stored in a large, water-filled basin that is

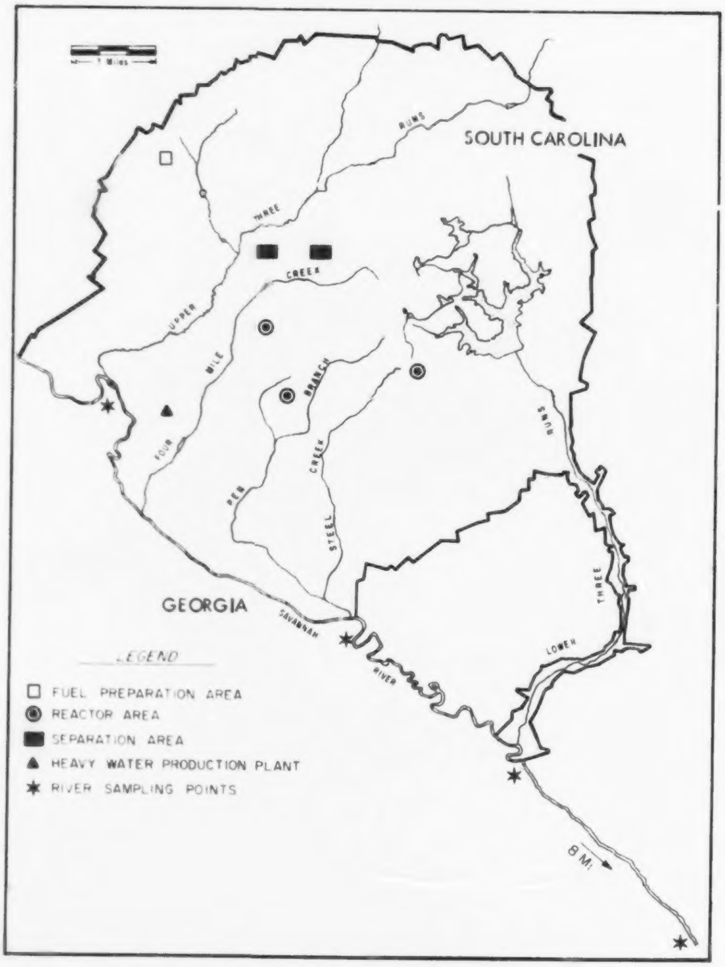
Miles
SOUTH CAROLINA
UPPER THREE RUNS CREEK
FOUR MILE CREEK
PEN BRANCH
STEEL CREEK
LOWER THREE RUNS
GEORGIA
SAVANNAH RIVER
8 Mi
LEGEND
☐ FUEL PREPARATION AREA
◎ REACTOR AREA
■ SEPARATION AREA
▲ HEAVY WATER PRODUCTION PLANT
✱ RIVER SAMPLING POINTS

Figure 6. SRP production and effluent streams

purged to maintain clarity and to control water temperature. Newly discharged fuel is placed into an isolated section of the basin that is equipped with a water circulating system. Portable filters and deionizers are provided to remove a large percentage of the radionuclides, and a heat exchanger is used to control basin water temperature. Tritium from the irradiation of the D_2O moderator accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the contribution to the Savannah River results in concentrations less than 1 percent of the AEC standard.

The Beaufort-Jasper Water Authority operates a treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 1.9 nCi/liter (0.06 percent of the AEC standard) during the January–June period. The annual radiation exposure of an individual in this population due to the consumption of 1.2 liters per day of water containing the very low concentration of tritium is 0.17 mrem (this exposure may be compared with 20 mrem per year from natural potassium found in the body of all persons or with the 170 mrem per year specified by the Federal Radiation Council as the annual dose guide for members of the public).

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.1 pCi/liter) and beta radioactivity (5 pCi/liter) were essentially the same as those observed before plant startup. The higher than average alpha activity found in some drinking water supplies (for example, 8.2 pCi/liter at Jackson) was due to naturally-occurring radioactivity, primarily thorium-228 and its short-lived daughter products. Analyses of public drinking water for tritium by a new, more sensitive method detected measurable, but very low levels of tritium in the water supplies derived from surface water (maximum of 750 pCi/liter). Concentrations of tritium in water supplies using only deep wells were less than the sensitivity of the analysis (400 pCi/liter). Previously, tritium was below the former limit of detection (1,000 pCi/liter) in all drinking water samples. Radioactivity in public water supplies data is presented in table 5.

Table 5. Radioactivity in public water supplies, SRP April 1971

Sampling points	Source of water	Alpha radio-activity[a] (pCi/liter)	Non-volatile beta radio-activity[b] (pCi/liter)	Tritium[c] (pCi/liter)
Aiken	Stream, well	2.7	6	750
Allendale	Deep well	ND	ND	ND
Augusta	River	.3	ND	650
Barnwell	Deep well	.5	ND	ND
Bath	Lake	1.8	6	ND
Blackville	Deep well	.5	ND	ND
Clearwater	Lake	.7	ND	650
Jackson	Deep well	8.2	18	ND
Langley	Stream	3.6	7	430
New Ellenton	Deep well	1.3	ND	ND
North Augusta	River	.4	ND	500
Sardis	Deep well	ND	4	ND
Waynesboro	Stream	ND	8	580
Williston	Deep well	2.2	4	ND
Average		1.6	6	

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.

[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.

[c] AEC radiation protection standard—3 μCi/liter; sensitivity of analysis—400 pCi/liter.

ND—less than the sensitivity of analysis.

River water, analyzed weekly, was sampled continuously above and below the plant as shown in figure 6. Concentrations of alpha and nonvolatile beta radioactivity in river water for the past year are presented in table 6. The upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests; the downstream measurements reflect the operation of the SRP reactors. Average concentrations of specific radionuclides found in river water during January–June 1971 appear in table 7.

Tritium, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents.

Table 6. Radioactivity in Savannah River water, January–June 1971

Sampling points	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	January–June 1971			July–December 1970	January–June 1971			July–December 1970
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.4	ND	ND	ND	12	ND	4	4
8 miles downstream from Lower Three Runs Creek	.6	ND	ND	ND	13	ND	6	7

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, less than the sensitivity of analysis.

Table 7. Average concentration of radionuclides in Savannah River water January–June 1971

Radioactivity	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	Percent AEC standard at Highway 301
Tritium	600	680	5,800	0.19
Sulphur-35	5.0	ND	ND	< .01
Chromium-51	4.3	ND	ND	< .001
Manganese-54	.4	ND	ND	< .0004
Cobalt-60	1.4	ND	ND	< .005
Zinc-65	1.1	ND	ND	< .001
Strontium-89	.3	ND	.7	.02
Strontium-90	.01	.6	.9	.30
Zirconium-niobium-95	.5	ND	ND	< .001
Ruthenium-103,-106	3.2	ND	ND	< .03
Iodine-131	.2	ND	ND	< .07
Cesium-134,-137	.6	ND	.2	.001
Barium-lanthanum-140	1.6	ND	ND	< .01
Cerium-141,-144	2.5	ND	ND	< .02
Neptunium-239	2.2	ND	ND	< .002

ND, nondetectable, less than sensitivity of analysis.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavywater moderator in the reactors. The concentration of tritium in river water averaged 0.19 percent of the AEC standard.

Fish in Savannah River

Fish traps were maintained upstream, adjacent to, and downstream from the Savannah River Plant effluents, throughout this period. Individual whole fish were analyzed by gamma spectroscopy for cesium-137 and other gamma-emitting radionuclides. Bone from each specimen was composited monthly for strontium-89 and strontium-90 analysis. Concentrations of specific radionuclides in fish are summarized in table 8. The radioactivity in bone and flesh indicates some minor contribution by SRP. The concentrations, however, are of minor significance when referenced against intake guides defined by the AEC radiation protection standard.

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route

Table 8. Radioactivity in Savannah River fish, January–June 1971

Location	Number		Type of sample	Concentration (pCi/g wet weight)					
				Cesium-137				Strontium-89,-90	
				Bream[a]		Catfish[b]		Bream and catfish	
	Bream	Catfish		Maximum	Average	Maximum	Average	Maximum	Average
Above plant boundary	18	75	Bone	NA	NA	NA	NA	23	12
			Flesh	25	3.2	15	3.6	NA	NA
Adjacent to plant	14	27	Bone	NA	NA	NA	NA	21	13
			Flesh	18	6.3	21	6.6	NA	NA
Below plant at Highway 301	89	22	Bone	NA	NA	NA	NA	9	8
			Flesh	20	4.5	11	4.9	NA	NA

[a] Shellcracker, bluegill, and redbreast (Lepomis).
[b] Predominantly yellow cat (Ictalurus).
NA, no analysis.

(these are not designated on figure 6). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and at the 25-mile radius locations, as compared to 0.1 pCi/g at both locations during the last half of 1970; gamma-ray emitters averaged 38.4 and 32.4 pCi/g, respectively, as compared to 11.1 and 9.9 pCi/g for the last half of 1970. Radioactivity in grass samples is presented in table 9.

Table 9. Radioactivity in vegetation, January–June 1971

Radionuclides	Sensitivity of analysis (pCi/g dry weight)	Concentration (pCi/g dry weight)			
		Plant perimeter (7 locations)		25-mile radius (7 locations)	
		Maximum	Average	Maximum	Average
Alpha emitters	0.10	1.1	0.2	0.7	0.2
Cesium-137	.3	3.8	1.6	1.1	.8
Cesium-141,-144	1.0	27.5	13.0	14.1	10.4
Ruthenium-103,-106	1.4	4.4	3.1	5.0	2.8
Beryllium-7[a]	3.0	35.5	16.3	23.1	14.6
Zirconium-niobium-95	.5	11.0	4.4	5.2	3.8

[a] A natural radionuclide.

Milk

Milk was sampled at four dairies within a 25-mile radius of the Savannah River Plant (figure 3). Samples were collected biweekly and analyzed for tritium and radioiodine. Analyses were made quarterly for strontium-90 and monthly for cesium-137. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from the analyses of milk for radioactivity during January–June 1971 are shown in table 10.

Average concentrations of the radionuclides in milk were 9 pCi/liter of strontium-90 (3.0 percent of the AEC standard) and 18 pCi/liter of cesium-137 (0.09 percent of the AEC standard) compared to 12 pCi/liter of strontium-90 and 40 pCi/liter of cesium-137 during the last half of 1970. Iodine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the Pasteurized Milk Network for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1.3 nCi/liter) was 0.04 percent of the AEC standard for water.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1971 data (table 11) are characteristic of measurements observed at individual stations for the past several years.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation

Table 10. Radioactivity in milk from local dairies, Savannah River Plant January–June 1971

Sampling points	Concentration (pCi/liter)							
	Tritium[a]			Strontium-90[b]		Cesium-137[c]		
	Maximum	Minimum	Average	March	June	Maximum	Minimum	Average
Aiken	960	ND	460	7	7	20	10	16
Barnwell	5,500	1,000	2,800	NS	11	26	16	21
North Augusta	4,700	350	1,500	NS	17	30	8	20
Waynesboro	1,900	390	1,000	8	NS	20	9	15
Major distributors[d]	1,400	200	730	8	8	22	10	17

[a] Sensitivity of analysis—200 pCi/liter; AEC standard—3,000 nCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter; AEC standard—300 pCi/liter.
[c] Sensitivity of analysis—0 pCi/liter; AEC standard—20 nCi/liter.
[d] Milk produced in local dairies but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Table 11. Environmental gamma radiation Savannah River Plant, January–June 1971

Sampling points	Gamma radiation (mR/24 h)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.25	0.11	0.20
B	.27	.08	.16
C	.20	.13	.16
D	.19	.12	.16
E	.20	.11	.18
Average			.18
25-mile-radius:			
Aiken Airport	.18	.08	.15
Aiken State Park	.15	.12	.14
Allendale	.19	.11	.15
Barnwell	.20	.16	.18
Bush Field	.25	.12	.19
Langley	.23	.14	.17
Sardis	.21	.14	.17
Waynesboro	.21	.08	.15
Williston	.20	.14	.17
Highway 301	.25	.12	.20
Average			.17

or was obscured by fallout from offsite sources. Beta radioactivity in air, which showed no relationship with plant operations and was due to global fallout, was slightly higher than that observed for the same period of 1970 and was a two-fold increase over the previous 6-month period. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed 0.3 percent of the AEC radiation protection standard.

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Reported Nuclear Detonations, February 1972

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations reported by the U.S. Atomic Energy Commission for February 1972 for the United States.

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals originated at approximately midnight, EST, February 9, 1972, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the intermediate yield range of 20 to 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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